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EDITORIAL NOTES.

AMONGST the long list of deferred Birthday Honours is that of a Knighthood to the well-known geologist (who has attained his 81st year), William Boyd Dawkins, M.A., D.Sc. (Oxford), Hon. D.Sc. (Man.), F.R.S., F.S.A., F.G.S., M.Inst.M.E., Assoc.Inst.C.E., Hon. Professor of Geology and Palæontology in the Victoria University, Manchester. Professor Boyd Dawkins is one of the few surviving geologists who, with Sir A. Geikie, Sir Ray Lankester, and Dr. Henry Woodward, assisted in giving birth to the first number of the GEOLOGICAL MAGAZINE on July 1, 1864, fifty-five years ago. We offer Sir William Boyd Dawkins our heartiest congratulations on this latest distinction conferred upon him by the King.

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As a result of recent great developments in the Departments of Geology and Geography at Cambridge several new appointments have been made. In view of the recent establishment of a Geography Tripos, and in order to provide a single responsible head for the department, the General Board of Studies have recommended the establishment of a Royal Geographical Society Readership in Geography, to which it is proposed to appoint P. Lake, M.A., of St. John's College, hitherto Royal Geographical Society University Lecturer in Regional and Physical Geography. This latter lectureship is to be suspended for the present. F. Debenham, of Gonville and Caius College, has also been appointed Royal Geographical Society University Lecturer in Surveying and Cartography. It is to be noted that both these gentlemen are well-known geologists. In the Department of Geology a new University Lectureship in Economic Geology has been created, to which R. H. Rastall, M.A., of Christ's College, has been elected. The Woodwardian Professor has chosen as his assistant T. C. Nicholas, O.B.E., M.C., M.A., of Trinity College, while the new Demonstrator in Petrology is J. M. Wordie, M.A., of St. John's College.

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EARLY in August it was announced that the Government have appointed a Departmental Committee to inquire into the present position of the non-ferrous mining industry in this country. This is a subject on which a great deal has been written in the technical and general press, and there can be no doubt that the changed

conditions of the last few months have left matters in a very complicated and unsatisfactory position. This was probably inevitable under the circumstances, and we trust that the Committee will be able to find some way of putting the industry on a sounder financial basis. The writer of these lines has lately had an opportunity of seeing something of the tin-mining industry of Cornwall, and has formed certain opinions on the subject. However, in view of the approaching Government investigation this is not the time to expound these opinions. It must suffice here to say that geologists will await with much interest the results of the comprehensive scheme of exploration and development now to be undertaken in the hitherto untried region between Camborne and the sea. These investigations promise to yield results of great importance, and will in all probability throw some light on the question of the underground relations of the masses of granite now visible at the surface in Cornwall. This is a problem of much interest to petrologists and structural geologists, apart from its economic importance, in view of the fact that the richest deposits of tin are as a rule closely associated with the granite-slate contact.

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In the list of members of the Committee mentioned in the preceding paragraph we are glad to see the name of Dr. F. H. Hatch, whose interesting lecture on recent developments in the iron-ore industry of this country we print in the present number. Dr. Hatch has a very wide knowledge of mining matters in many parts of the world in connexion with many kinds of metalliferous ores, and his help will be of great value to the Committee. As is well known Dr. Hatch rendered most valuable services to the country during the War in relation to the development of home iron-ores and other necessary materials to counteract the falling off in imported supplies, while he is also an active member of the recently instituted Mineral Resources Bureau.

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It is perhaps not yet too late to remind our readers that the meeting of the British Association takes place at Bournemouth from September 9 to 13. This year the meeting will again be held under more or less normal conditions, although the programme of official functions is somewhat smaller than of old. Many members will no doubt consider this an advantage rather than otherwise. It is satisfactory to observe that it has been found possible to obtain accommodation for practically the whole of the work of the meeting in one building, namely, the Municipal College. A series of citizens' lectures are to be given in co-operation with the Workers' Educational Association, and one of these is to be delivered by Professor S. H. Reynolds on the scenery and geology of the Isle of Purbeck; this should prove an attractive subject. Several excursions have been arranged to places of geological interest, which abound in the neighbourhood, including such classic localities as Lulworth Cove and Kimmeridge. It would be difficult to find a region more attractive from this point of view.

ORIGINAL ARTICLES.

I.—Recent Iron-ore Developments in the United Kingdom.[1]

By Dr. F. H. Hatch.

WHILST the basis of the prosperity of a country is admittedly agriculture, its industrial growth is founded on mineral resources, and its participation in the world's markets is chiefly dependent on the extent to which these raw materials can be applied to home manufactures.

It is true that the first historical reference to this country mentions the export of tin from Cornwall and that Great Britain's production and export of copper in the early part of the nineteenth century were the largest in the world; but for its modern industrial pre-eminence this country is undoubtedly indebted to its coal and ironstone.

The cheap manufacture of iron and steel in this country was greatly aided by the providential dispensation that the ironstone was so closely associated in nature with the fuel required to smelt it that the factor of transportation was practically eliminated.

But the gradual exhaustion of the richer blackbands and clay ironstones of the Carboniferous formation, and the introduction of the Acid Bessemer Process of steel manufacture, which requires a pure ore free from phosphorus and sulphur, made it necessary to find other sources of iron-ore supply. For many years the United Kingdom has been dependent for 30 per cent of the iron-ore used in its blast-furnaces, on foreign countries. Foreign ore plays even a bigger rôle than at first sight appears, since it contains 50 per cent iron as against an average of 30 per cent for home ores. The importation of hæmatite, rich in iron and low in phosphorus, from Spain and the Mediterranean, has built up the big iron industries that are engaged in the manufacture of steel by the Acid process in South Wales, on the North-West coast, on the North-East coast, and in Scotland, where the ports of Cardiff, Port Talbot, Whitehaven, Barrow, Middlesbrough, Newcastle, and the Clyde, situated in close proximity to an ample supply of labour, enable foreign ore and native coal to be easily assembled and cheaply handed.

Cheap water-transport is the basis of the successful importation of foreign ore. Its importance may be illustrated by the development of the great iron and steel industry of the United States. In that country the ore is brought in 10,000-ton boats from the north end of Lake Superior, where it occurs in great abundance, to Chicago and Pittsburg, where there are ample supplies of fuel and labour. In 1916 as much as 64 million tons of iron-ore were conveyed in this manner.

In the case of the United Kingdom, ocean-transport was found to have its drawbacks when the War broke out; and the scarcity of ship-tonnage, which resulted from the activity of the enemy submarines, raised the cost of imported ore from about 20*s*. (at which Best Bilbao ore ruled in British ports in 1914) to an actual price of

[1] A lecture delivered at the Royal School of Mines on May 27, 1919.

over £6 per ton, although (under the cloak of Government subsidies) it figured at a lower level. At one period of the War the supply from these sources threatened to be cut off altogether.

To meet this situation an increased development of the Jurassic ironstones of this country was decided on. The chart shows the fall in production to the end of 1916, and the subsequent rise due to the introduction of this policy.

These ironstones, although abundant and cheaply worked, are what the ironmasters term "lean", that is to say they are low in iron, averaging only 28 per cent of that metal. Moreover, they have a high phosphorus and sulphur-content and, for the most part, are rather siliceous.

There are two classes of steel, which are named "acid" and "basic" respectively, according to the process used in their manufacture. Acid steel is produced from hæmatite pig-iron, practically free from phosphorus and sulphur, in furnaces provided with a siliceous (or acid) lining. Basic steel, on the other hand, is produced from pig-iron containing both these injurious ingredients, which are removed in the course of manufacture by means of a basic lining to the furnaces. The large increase in the production of phosphoric ores was reflected in an increased output of basic steel as shown on chart.

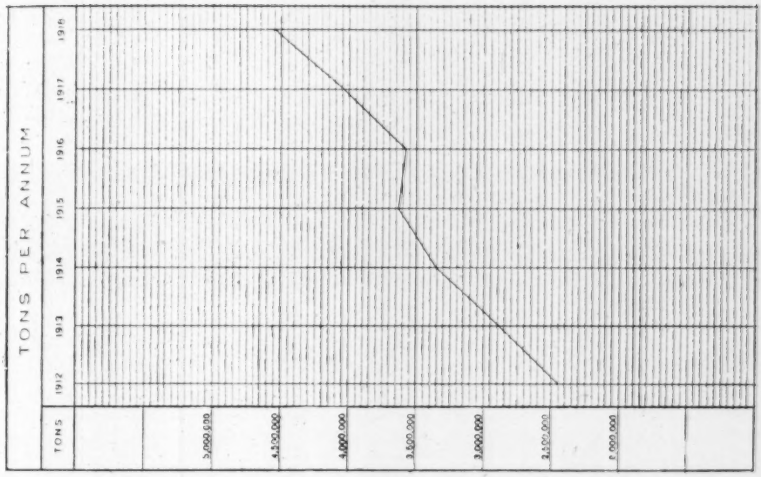
The increased production of the domestic phosphoric ores brought about by the War raised many difficult problems. In the first place it necessitated a different metallurgical treatment. This involved, as already explained, the substitution of basic-lined steel-furnaces for those of the acid type, with consequent increased supplies of suitable refractory materials. It also involved large additional supplies of fuel for smelting and of limestone for fluxing the ore in the blast-furnaces.

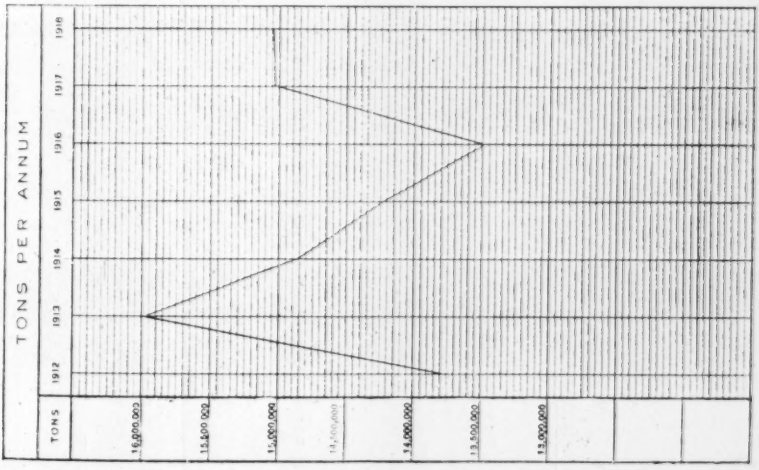
Special difficulties arose with regard to magnesite and magnesite bricks. Prior to the outbreak of war the magnesite brick industry was almost wholly in the hands of the Austrians. The Austrians possess in their own country extensive deposits of magnesite peculiarly suited for brick-making, and they have devoted both skill and money to the perfecting of their products, with the result that before the War they commanded practically the entire custom of the steel trade in this country. To make up for the loss of the Austrian material arrangements were made by the Ministry of Munitions for the manufacture in this country of magnesite bricks, and the raw material was obtained from Eubœa in Greece, and from Salem in Madras.

To furnish the required dolomite and limestone new quarries were opened up in this country.

With regard to labour a new supply had to be found not only to work the new quarries of ironstone, limestone, dolomite, etc., but also to build the railways required to open them up, to erect extensions to existing plant, to man the new works, to reline furnaces, etc., and this in face of the incessant and urgent calls of the Army to fill the gaps in the fighting line.

Considerable use was made of prisoner labour. The difficulty with prisoners was to induce them to work. On account of the Army


BASIC STEEL.
Production in the United Kingdom
TONS PER ANNUM
TONS
1912
1913
1914
1915
1916
1917
1918
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000


IRON ORE
Total production in the United Kingdom.
TONS PER ANNUM
TONS
1912
1913
1914
1915
1916
1917
1918
16,000,000
15,500,000
15,000,000
14,500,000
14,000,000
13,500,000
13,000,000

regulations work could neither be compelled by force nor by a reduction of rations. The difficulty was overcome by the introduction of piece-rates ; but only to a limited extent, as there was no outlet for surplus earnings in the canteens, food supplies having been cut down on account of the general food shortage.

The dearth of quarrymen led to active steps being taken in responsible quarters to supplement and to increase the efficiency of manual labour at the quarries by the provision of mechanical appliances for stripping, breaking, and loading the ironstone.

In these open-workings, the output per man employed varies with the thickness of the ironstone bed, the amount of cover to be removed, the use made of mechanical appliances, and the condition of the weather. The weather materially affects the output, especially where hand-labour is concerned. From returns made to the Ministry of Munitions in December, 1917, it appears that the average output in the Midlands per man employed was five tons per shift, and that it ranged from 3·8 tons where hand-labour was alone employed, to over fifteen tons where mechanical excavators were in use under favourable conditions. The actual saving of manual labour which resulted from the installation of mechanical plant in the ironstone quarries during the War is estimated to have been equivalent to over 3,000 men.

The Jurassic ironstones have a wide distribution both in this country and on the continent. In 1913 Germany mined, in Lorraine and Luxemburg, 28,000,000 tons of Minette ores of Jurassic age, out of a total production of 36,000,000 tons of iron-ore, while she imported in addition 3,800,000 tons of the same ore from Briey. Without the Lorraine iron-ore basin, which she stole from France in 1871, Germany would have been unable to go to war, and she took care to secure the remaining portion of the field (i.e. the Longwy and Briey basins) soon after the commencement of hostilities. One of the best guarantees for future Peace is the provision in the Peace treaty that no portion of this iron-ore field remains in German hands.

In England the Jurassic formation stretches as a broad band from the coast of Yorkshire to that of Dorset. The ironstones occur on four different horizons :—

THE JURASSIC IRONSTONES.

Name of Ironstone Bed.	*Position in Jurassic System.*	*Where worked.*
Westbury and Dover.	Corallian.	Not now worked for iron.
Northampton Ironstone.	Lower part of the Inferior Oolite.	Rutlandshire and Northampton.
Marlstone.	Upper part of the Middle Lias.	Cleveland in Yorkshire, South Lincolnshire, Leicestershire, and Oxfordshire.
Frodingham Ironstone.	Middle part of the Lower Lias.	North Lincolnshire.

The Corallian ironstones are at present not worked as a source of iron, although the Westbury bed is quarried for use in the

purification of illuminating gas. In the Kent coalfield a bed of oolitic ironstone, 16 feet thick, has been cut in the shaft of the Dover Colliery at a depth of 593 feet from the surface. This stone contains, as mined, 33 per cent of iron, 15 per cent of silica, 9 per cent of lime, 0·45 per cent of phosphorus, and 0·05 per cent of sulphur. With regard to mechanical condition, it is rather friable and may have to be sintered or briquetted before use in the blast-furnace. On account of its favourable situation in a coalfield and on the seaboard it is most probable that steps will be taken to work this deposit in the near future.

The other Jurassic ironstones are all worked, and in 1917 accounted for over 80 per cent of the total output of iron-ore in the United Kingdom, the remaining 20 per cent being made up of Hæmatite, mined in Cumberland and Lancashire (10½ per cent); Blackband and Clay-ironstone, mined in the English and Scotch coalfields (8 per cent); and sundry ores mined in Wales, Forest of Dean, Devonshire, Weardale, and Ireland (1½ per cent).

TABLE SHOWING RELATIVE PRODUCTION OF DIFFERENT CLASSES OF BRITISH IRON-ORES.

	%
Jurassic ironstones	80·0
West coast (Hæmatite ore)	10·5
Blackband and Clay-ironstone in coalfields	8·0
Sundry ores	1·5
	100·0

Taking the Jurassic ironstones in descending order the proportion in which they were worked (in relation to the total production of the United Kingdom) in 1917, and their iron-content, are as shown in the table:—

TABLE SHOWING RELATIVE PRODUCTION AND IRON-CONTENT OF THE JURASSIC IRONSTONES.

Ironstone.	*Ratio to Total Production.*	*Average Iron Content (as mined).*
	%	%
Inferior Oolite (Northampton and Rutland)	21	32
Middle Lias (Cleveland)	32	28
Middle Lias (South Lincolnshire, Leicestershire, and Oxfordshire)	9	25
Middle Lias (Raasay)	0·5	23
Lower Lias (North Lincolnshire)	18	23
	80·5	27·6

The average composition of the different Jurassic ironstones is shown in the following table:—

TABLE SHOWING AVERAGE ANALYSES OF JURASSIC IRONSTONE AS RECEIVED AT THE WORKS.

	Inferior Oolite (Northampton).	*Middle Lias (Cleveland var.).*	*Middle Lias (Leicester var.).*
	%	%	%
Fe	32·5	28·1	25·2
Mn	0·24	0·41	0·23
SiO_2	14·7	11·8	10·9
Al_2O_3	6·1	10·2	8·0
CaO	2·7	4·7	9·6
MgO	0·4	3·5	0·6
S	0·10	0·26	0·11
P	0·60	0·47	0·25
Moisture	15·2	6·8	16·4

	Middle Lias (Oxfordshire var.).	*Lower Lias. (Frodingham Stone).*	*Corallian (Dover Colliery).*
	%	%	%
Fe	24·0	22·7	33
Mn	0·27	0·96	—
SiO_2	10·2	8·1	15
Al_2O_3	7·6	5·1	—
CaO	12·2	18·2	9
MgO	0·6	1·0	—
S	0·06	0·16	0·05
P	0·23	0·31	0·45
Moisture	15·6	10·7	—

The *Northampton Ironstone* is, in general, high in silica and low in lime, and contains 0·1 of sulphur and 0·6 of phosphorus. In part, it is smelted locally with limestone or with limey ironstone, obtained in the district, to neutralise its siliceous character. Some is sent to Frodingham and some to Middlesbrough for smelting with the ironstone of those districts, but the greater proportion goes to furnaces in the coalfields of Staffordshire, Derby and Nottingham, South Yorkshire, and South Wales, to be smelted in admixture with the calcareous blackband and clay-ironstones of the Coal-measures and with tap-cinder.

The *Cleveland Ironstone* is also siliceous and requires lime to flux it. It is high in alumina and sulphur, and this feature militates against its use for making basic pig-iron, since the alumina-content makes it difficult to carry sufficient lime in the slag to ensure the production of a basic pig low in silicon and sulphur. To produce a suitable pig a considerable proportion of ores low in alumina, mainly of foreign origin, has to be added to the furnace charge. But, by using molten metal direct from the blast-furnace and desiliconizing it in a mixer, basic open-hearth steel can be made from Cleveland ores without admixture with foreign ores.

The *Frodingham Ironstone* almost invariably contains sufficient lime to be fluxed without the addition of limestone. It also carries about 1 per cent of manganese and can therefore be smelted without the addition of manganese ore. These self-fluxing properties make it a most valuable ore, in spite of its low iron-content, which averages only 22 per cent. The sulphur-content is 0·16 and the phosphorus 0·31.

The *Marlstone* of South Lincolnshire, Leicestershire, and Oxfordshire is on the whole a "limey" ironstone, and is often self-fluxing. In places, however, where the surface waters have leached out the lime, it is siliceous. Its phosphorus-content averages 0·25; sulphur, 0·1.

The following are average analyses of the limey and siliceous varieties respectively:—

	Limey Ironstone (Unweathered Marlstone).	*Siliceous Ironstone (Weathered Marlstone).*
Fe	22·43	27·91
Mn	0·24	0·28
SiO_2	9·39	13·28
Al_2O_3	7·36	8·03
CaO	14·89	3·79
MgO	0·61	0·42
S	0·06	0·05
P	0·23	0·22
Moisture	13·85	20·56
Difference (Combined Water, CO_2 and O)	30·94	25·46
	100·00	100·00

It will be seen that chemically the change from the limey to the siliceous type, which is brought about by weathering, consists of a loss of lime and carbon dioxide and an increase of all the other constituents—iron, silica, alumina, and moisture. Physically, the change is from a compact bluish-green ironstone, consisting of carbonate of iron and lime, to a porous brown hydrated oxide of iron or limonite. In the quarries the horizontal line of demarkation between the two varieties is often clearly discernible. Where, however, the "cover" consists of clay, shale, or other impermeable material of sufficient thickness to hinder the downward percolation of the surface water, hydration and oxidation of the ironstone are prevented, and the green limey variety in that case extends right up to the junction of the ironstone with the cover.

Before charging into the blast-furnaces, the ironstone of all the districts is usually calcined, although a certain proportion is fed raw into the furnaces. The object of calcining is, in the case of the oxidized stone, to eliminate the water. In the case of the green carbonate stone, the effect is to drive off the carbon dioxide and convert the iron to peroxide. The loss on calcination is roughly 25 per cent of the weight. Consequently, calcination at the point of origin saves railway carriage. It has the disadvantage, however, on the one hand, that exposure to the weather may result in the calcined material absorbing a considerable amount of water on its journey to the furnaces, and, on the other, that the handling and transportation of the dry material may engender a considerable quantity of dust, which is objectionable to the men engaged in its discharging, and tends to choke up the furnaces.

Calcining raises the percentage of iron considerably. If the loss on calcination is 25 per cent, the increase is one third of the percentage of iron in the raw stone. Thus, the 32 per cent, which is the average iron content of the raw Northampton stone, becomes 43 in the calcined material; the 28 per cent of the Cleveland stone becomes 37; the 24 per cent of the Oxfordshire stone, 32; and so on. It follows that the use of calcined stone increases the output of pig-iron per furnace. Furthermore, there is a saving of fuel in the blast-furnace.

The calcining is either effected in Gjers or Davis Colby kilns, with or without forced draught, or in open heaps—"clamps", as they are termed in Northamptonshire. It is a slow roasting process, and the fuel required is about 1½ cwt. of coal to the ton of ironstone.

The Jurassic ironstones, although poor in iron, are valuable because of their considerable thickness and widespread occurrence at only a slight depth below the surface. With the exception of the Cleveland district of Yorkshire, where the ironstone is now mined underground, the workings are almost everywhere at the surface, the ironstone being quarried after stripping off an overburden of soil, sand, or clay as the case may be. Since the angle of the dip is usually small or, in other words, the beds are practically horizontal, considerable areas can be worked before the overburden becomes too great for removal at a reasonable cost. As much as 60 feet of soft material (sand or clay) can be removed and, under favourable conditions, probably 100 feet will be removed.

The different beds of ironstone vary considerably in thickness. The thickest is the Frodingham bed in North Lincolnshire. This ironstone is 25 to 30 feet in thickness, and consequently can be worked very cheaply by mechanical excavation. Before the War the cost of the stone in wagons at the quarries (exclusive of royalty) was not more than 1*s*. per ton. Probably it is double that now.

The workable part of the Northampton ironstone varies from 6 to 13 feet, averaging about 8 feet. The lower portion of the bed is generally too poor in iron for economic extraction. During the early part of the War it was sold at 3*s*. 3*d*. per ton of raw stone. Subsequently the price was fixed at 3*s*. 9*d*. per ton, plus ½*d*. for every 1*s*. 3*d*. rise in wages above the rate current on the 12th November, 1917.

The Cleveland Main Seam varies from 5½ to 12 feet. It is mined at depths ranging from 100 to 600 feet, the mines being worked on the bord and pillar system. The cost of the stone at the pit's mouth is now about 10*s*. per ton, as against 2*s*. to 4*s*. for the quarried stone.

The output per man employed on surface and underground in the Cleveland mines averages 2·2 tons per shift as against 4 to 15 tons for the quarried stone.

In addition to the Main Seam, other ironstone beds both above and below the Main Seam, have from time to time been worked on a small scale, in the Cleveland district. Their geological relation to the Main Seam is shown in the following table:—

IRONSTONES OF THE CLEVELAND DISTRICT.

Geological Formation.	*Name of Seam.*	*Thickness of Seam.*	*Thickness of intervening Strata.*
		Feet.	Feet.
Inferior Oolite	Top or Oolite Seam	4-9	
Upper Lias	Strata		260
	Main Seam	5½-12	
Middle Lias	Shale		2-6
	Pecten Seam	1½-6	
	Shale		3-7
	Two-foot Seam	1½-2½	
	Shale		20-30
	Avicula Seam	0-3	

As compared with 1916 figures the production of the Jurassic ironstones as a whole was increased by 45,000 tons per week, equivalent to 2⅓ million tons per annum. The increase reached this maximum in the first half of the year 1918. But it was not possible to maintain production at that figure on account of the calls of the Army on labour. The increase was made mainly in Northampton, Rutlandshire, and Leicestershire, the quarries in these counties accounting for 59 per cent of the total increase; but Cleveland was responsible for 26 per cent and Oxfordshire for 9 per cent.

The following table, showing the production of the Jurassic ironstones in relation to the total production of iron-ore in the United Kingdom during 1918, is compiled from returns made to the Ministry of Munitions.

PRODUCTION OF IRON-ORE IN THE UNITED KINGDOM DURING 1918.

	Tons.	%
Cleveland	4,570,892	
North Lincolnshire	2,639,712	
Midlands	4,954,087	
Raasay	88,047	
Total Jurassic Ironstones	12,252,738	80
Coalfields	1,119,215	
Wales and Forest of Dean	85,419	
Miscellaneous (Ireland, County Durham, and Devonshire)	37,039	
West Coast (Hæmatite)	1,549,962	
Total non-Jurassic Ores and Ironstones	2,791,635	20
Grand total	15,044,373	

With regard to the non-Jurassic iron-ores of this country, the most important are the hæmatite deposits of Cumberland and Lancashire. These ores are remarkable for their richness in iron and their freedom from both phosphorus and sulphur, and therefore furnish a pig-iron very suitable for the Acid Bessemer process, and yield an exceptionally pure steel. They are consequently in great demand; and this demand was emphasized during the War by the difficulty at one time experienced in securing sufficient supplies of hematite ore from Spain. Every effort was therefore made to push production to the utmost and many abandoned mines were reopened in order to extract the pillars.

The deposits occur in masses of irregular shape in the Carboniferous limestone, a formation which in this district rests unconformably on the old Skiddaw Slates, and is itself concealed in places by overlying Coal-measures and red sandstones, or by boulder clay. The existing mines are situated between Lamplugh in Cumberland and Ulverston in Lancashire, a distance, from north to south, of 35 miles.

No doubt, besides the known deposits, many undiscovered ore-bodies exist in the Carboniferous Limestone, that can only be found by systematic prospecting by boring. Already before the War, borings through the red sandstones had disclosed, south of Egremont, some of the largest ore-bodies that have been found in either county, with the possible exception of that worked by the Hodbarrow Mine. The Beckermet, Ullcoats, and Ullbank companies are now engaged in developing and working these deposits.

Since the Carboniferous Limestone is of widespread occurrence in the United Kingdom, it might have been expected that valuable hæmatite deposits would have been discovered in other parts of the country. With the exception, however, of deposits of limited extent in South Wales and in the Forest of Dean, this has not proved to be the case. The South Wales hæmatite was worked fairly extensively to the north-west of Cardiff between the years 1840 and 1870, and yielded in the aggregate some three million tons of ore. But with the exception of the Llanharry mine, which still continues to produce about 60,000 tons of ore per annum, all work has stopped on these mines.

In the Forest of Dean the deposits, or "churns" as they are locally called, are chiefly characterized by their irregularity and small dimensions. The output of this field is quite unimportant, being less than 300 tons a week.

The only other important sources of iron-ore in this country are the blackband and clay-ironstones, associated with coal-seams in the English and Scotch coalfields. These ores, which once played so big a rôle in the British iron industry, are now of small importance owing to the exhaustion of the larger and more profitable seams.

The total output from Scotch and English coalfields amounts to 1,120,000 tons per annum, of which 357,000 tons come from Scotland and 695,000 tons from North Staffordshire. In Scotland the ore is derived from narrow seams of blackband and clayband and from "balls" of ironstone brought down in working the coal.

In North Staffordshire there are (1) small seams of blackband which are associated with sufficient combustible material to permit of calcination in the open without the addition of further fuel, and (2) seams of clay-ironstone which require the addition of fuel for calcination. By calcination of these ironstones two products are obtained, (1) a high-grade material, containing over 60 per cent iron, which is used for bottoming and fettling puddle-furnaces and for oxidizing purposes in the steel furnaces; and (2) a slightly inferior quality, containing 55 per cent of iron, which goes to the blast-furnaces.

In the industrial recuperation of this country now that the War is over, the working of the low-grade Jurassic deposits which it is

fortunate in possessing, is destined to play a great part. This has been rendered possible by the great extensions to iron and steel works that have been initiated with Government assistance during the War. These works have been planned on the most modern lines, and possess on the same site by-product coke ovens, blast-furnaces, steel works, and rolling mills. They are designed for the basic process of steel-making and will be fed with home ores. In choosing the sites for these works regard has been paid to the situation of the raw materials—ore, fuel, and flux—required to supply them. On the completion of these extensions there should be no necessity for this country to import a single ton of foreign steel. Before the War something like 2½ million tons of steel, in the form of slabs, blooms, and billets, were imported into this country annually, mainly from Germany.

But for success in this great undertaking cheap ore and fuel are essential and these can only be obtained, in face of the greatly augmented cost of labour and material, which is a legacy of the War, by an all-round increase in efficiency, embracing capital, engineering, and labour—capital by the installation of up-to-date equipment, engineering by improved mining methods, and labour by an increased output per man per shift.

These are the outstanding problems of the immediate future.

II.—A Low-level Glaciated Surface in the Eastern Himalaya.[1]

By J. W. Gregory, F.R.S.

At Christmas, 1917, I had the privilege, owing to the kindness of the Hon. Mr. W. W. Hornell, of a short visit into Southern Sikkim, during which I observed glacial striation at a lower level than has been previously recorded in the Himalaya. This occurrence is the more worthy of record since striated rock-surfaces are reported as scarce or absent from the Eastern Himalaya even at much higher levels. For courteous help and the use of the library of the Geological Survey of India I am indebted to Dr. H. H. Hayden, and references to some of the literature I owe to him and also to Mr. E. W. Vredenburg.

1. Ancient Moraines in Sikkim.

The existing glaciers of the Eastern Himalaya do not descend below the level of about 14,000 feet (e.g. Hooker, 1854, vol. i, p. 260); that they formerly extended much lower has been well known since the journey in Sikkim of Sir J. D. Hooker, who described and figured "stupendous" ancient moraines in the Lachung Valley at about 8,000 feet above sea-level (Hooker, 1854, vol. ii, pp. 103–4), in the Lachen Valley at about 8,800 feet, and across the Yangma Valley at 11,000 feet (ibid., vol. i, p. 232, pl. opp. p. 232). The moraines in the Lachen Valley have been revisited by Blanford (1871, p. 395), by Bose (1891, p. 219), and by Garwood (1903, p. 298), who records their level as 8,790 feet; these Lachen

[1] The spelling of the place-names is in accordance with the map of Sikkim, 4 miles to 1 inch, Survey of India, 1916.

moraines appear to be the lowest known in Sikkim. Moraines are reported to occur in most of the high-level valleys of northern Sikkim. Thus Hooker remarked (1854, vol. i, p. 380), "I have described meeting with ancient moraines in every Himalayan valley I ascended, at or about 7,000 or 8,000 feet elevation, proving that at one period the glaciers descended fully so much below the position they now occupy."

Bose records abundant moraines, which were deposited by glaciers from Pandim, in the upper Jongri Valley about Thangme, 12,900 feet (Bose, 1891, pp. 55–9); but further down the valley at Yoksun, 5,500 feet, he failed (ibid., p. 61) "to find any evidence of glacial erosion". In his subsequent memoir on Sikkim Bose describes the moraines in the Lachen and Lachung valleys; he refers to the great terminal moraine in the Lachen Valley at the height of 8,790 feet as the lowest unmistakable evidence of former glacial action in Sikkim, though he remarks that the valley has "a glacial look about it" to the level of 7,000 feet (Bose, 1891, p. 219).

Professor Garwood's evidence is similar. During Mr. D. W. Freshfield's expedition around Kinchinjunga he crossed the Lachen moraines and confirmed their character and altitude (Garwood, 1893, p. 298 and map opp. p. 306).

2. Absence of Striated Surfaces.

Though moraines are abundant in the higher Himalayan valleys, striated rock surfaces appear very scarce. Their absence from Sikkim has been especially remarked by Blanford (1871, p. 401), who saw rounded rocks at about 15,000 feet near the Chang-o-Khang glacier, in the Lachung Valley; but he remarks, "I could never detect any polished or striated surfaces, such as are so common in Europe. Hooker has also noticed this"; and he adds that Medlicott failed to find them in the Western Himalaya.

Mr. P. N. Bose (1891, p. 57) repeats that ice-scratchings "are either indistinct or absent in the Himalayas"; he attributes the rapid destruction of moraines and removal of all traces of glacial action to the heavy rainfall (Bose, 1891, p. 219).

3. The Roche Moutonnée at Chakung.

Owing to the extreme wetness of the climate in Sikkim glacial striæ are doubtless soon obliterated when exposed to the weather. The glaciated surface at Chakung had been recently cleared during the reconstruction of the bridle-path owing to part of it having been carried away by a landslip. The locality (Fig. 1) is 8 miles north of Darjeeling, from which it is 22 miles distant by road; it is on the path from Chakung to Rinchenpong, on the steep descent from the Chakung bungalow to the Ratho River. The track passes some rounded surfaces of fresh rock, which are sharply separated from the overlying soil and are suggestive of glacial action. Four minutes before reaching the ninth mile post from Singla Bazar is a newly bared rock surface which shows typical glacial grooves and striæ. The rock is a dark phyllite: its strike is to 170° and its dip about 60° to south of west.

Both striæ and grooving trend to about 20° west of south. There has been considerable discussion as to whether it is possible to infer the direction of an ice movement from the shape of the glacial striæ; there is no single absolute criterion, but some of the scratches on this surface indicate that the movement was most probably from north to south and up the slope. The scratches are broadest and shallowest at the southern end. The possibility of the scratches having been made by some soil-cap movement down the hill-side was duly considered, but the evidence appears inconsistent with any such explanation and the striæ seem typically glacial.

FIG. 1.—Sketch-map of part of Southern Sikkim. ϕ, glaciated surface.

The hill faces north, opposite the valley of the Great Rangit River; the glaciated surface occurs at a point where ice coming down that valley would press against the hill-side. The nearest heights marked on the available maps, which were kindly shown me by Sir Sydney Burrard, F.R.S., then Director of the Trigonometrical Survey of India, are those of Chakung, 5,190 feet, and at the confluence of the Ratho and Rangit Rivers, 1,150 feet.

Being in India as a member of the Calcutta University Commission and not expecting any opportunity for geological work, I

had not taken an aneroid with me and could only estimate the height above sea-level from these two records. Mr. B. G. Gwyther, the Executive Engineer at Darjeeling, by careful aneroid observations, checked by simultaneous readings at Darjeeling, has determined the level of the bridge across the Ratho River on the Rinchenpong track as 3,300 feet, and of the ninth mile post as 3,462 feet. According to these determinations the roche moutonnée would be at about 3,550 or perhaps 3,600 feet above sea-level. The glaciated zone on the hill-side below Chakung probably extends as low as about 3,500 feet above sea-level.[1]

The glacier which made these striæ may have come from one of two sources: it may have flowed down the Ratho Valley from the high ground a few miles to the west; or it may have come from the snow-clad mountains of the Kinchinjunga group, of which the nearest bearing perpetual snow is Narsing, altitude 19,130 feet, 25 miles north of Chakung up the Great Rangit Valley. Glaciers from the southern side of the Kinchinjunga group appear to be the most probable source of the ice which reached Chakung; the glacier would have a straight course down the Rangit Valley until it flowed against the Chakung spur and made these north to south trending grooves and scratches.

That the ice was a local glacier from the hills around the head of the Ratho Valley suggested itself as a possibility, for the mountains there rise to such heights as Helu Peak 9,370 feet, a summit further west of 10,580 feet, and still further west to Singale La, 12,110 feet. P. N. Bose of the Indian Geological Survey, however, passed close by the summit of Helu Peak (Bose, 1891, p. 65) and Singale La (ibid., p. 47), and though he was on the watch for traces of glacial action he records none at these localities.

Though as previously remarked, old moraines are abundant in the valleys of Northern Sikkim, the lowest hitherto recorded are those at 8,790 feet in the Lachen Valley, about 12 miles from the Zemu Glacier, one of the greatest glaciers of the Kinchinjunga massif. The Lachen moraines are about 45 miles in a direct line from Chakung; so that the striated surface there is far to the south and on a much lower level than the lowest glacial evidence previously described in Sikkim.

4. Other Indications of Glacial Action near Chakung.

There are further indications and suggestions of glaciation in the neighbourhood of Chakung. Thus the spur of Langyong (which rises from the Great Rangit River to Rufula, a peak north-west of the conspicuous summit of Tendong), when seen from Rinchenpong appears to have a rounded ice-worn northern face at a height of

[1] Mr. Gwyther's results give the height of the Chakung bungalow as 4,825 feet; the trigonometrical station at Chakung is 5,189 feet. Major Tandy, of the Trigonometrical Survey Office for India, kindly tells me that rays were observed from that station in all directions; it was therefore not at the bungalow but along the ridge at a somewhat higher level, which accounts for the difference between Mr. Gwyther's determination and that usually assigned to the bungalow.

about 5,000 feet. Again the long spur to the south of the Kulhait Valley to the north-west of Rinchenpong is hummocked suggestively of glacial action at the height of about 4,500 or 5,000 feet.

The existence of hill spurs which end in flat triangular facets (Fig. 2), such as are well developed in the Rangit Valley near Badamtam north of Darjeeling, might be regarded as evidence of glacial action; but the numerous faceted spurs in Southern Sikkim appear clearly due to the truncation of spurs by rivers. As I have remarked elsewhere they are not proof of glacial action.

FIG. 2.—View from Badamtam across the valley of the Rangit, showing the level-crested ridges of the Sikkim peneplane and two of the spurs (*f*) faceted by river erosion.

Another occurrence which should be mentioned in this connexion is a train of huge boulders on the floor of the Rumman River above its junction with the Great Rangit River. One boulder that I measured is eight feet in diameter, and some are larger; they are situated at the height of slightly over 1,000 feet above sea level. The largest boulders are of gneiss, which, according to the map by Bose (1891, (2)) does not occur on the Rumman River until six miles up stream. The nearest outcrop is three miles away in the valley of the Little Rangit River. This boulder train has been noticed by Bose (1891, (1), p. 68); he attributes it to torrential river action. He remarks that these impetuous rivers can transport enormous boulders far from the parent rock (ibid., p. 57). According to his map the boulders must have been carried six miles down stream; and yet their forms are subangular. These boulders cannot be due to a landslip, as gneiss does not occur here on the sides of the valley; and if the boulders had been carried six miles down stream at least their lower surfaces which are protected from the weather should have preserved some trace of water action. That the boulders were deposited directly by ice appears improbable; but they may have been brought to the locality by ice, and have been dropped at some higher level, and subsequently lowered to their present position during the deepening of the valley by denudation. These boulders do not prove that ice deposited them where they now are; and the lowest level for which there is clear evidence of glacial action in Southern Sikkim is that of the glaciated surface below Chakung, at about 3,600 feet above sea-level.

5. Claims for Low-level Glacial Deposits in N.W. India and in Bengal.

Glaciation at a comparatively low-level has been claimed in the Western Himalayas and in Eastern Bengal, partly on the direct

evidence of moraines and striated rock-surfaces, partly on the indirect evidence of boulder beds and drifts, and partly on biological evidence. (Fig. 3.)

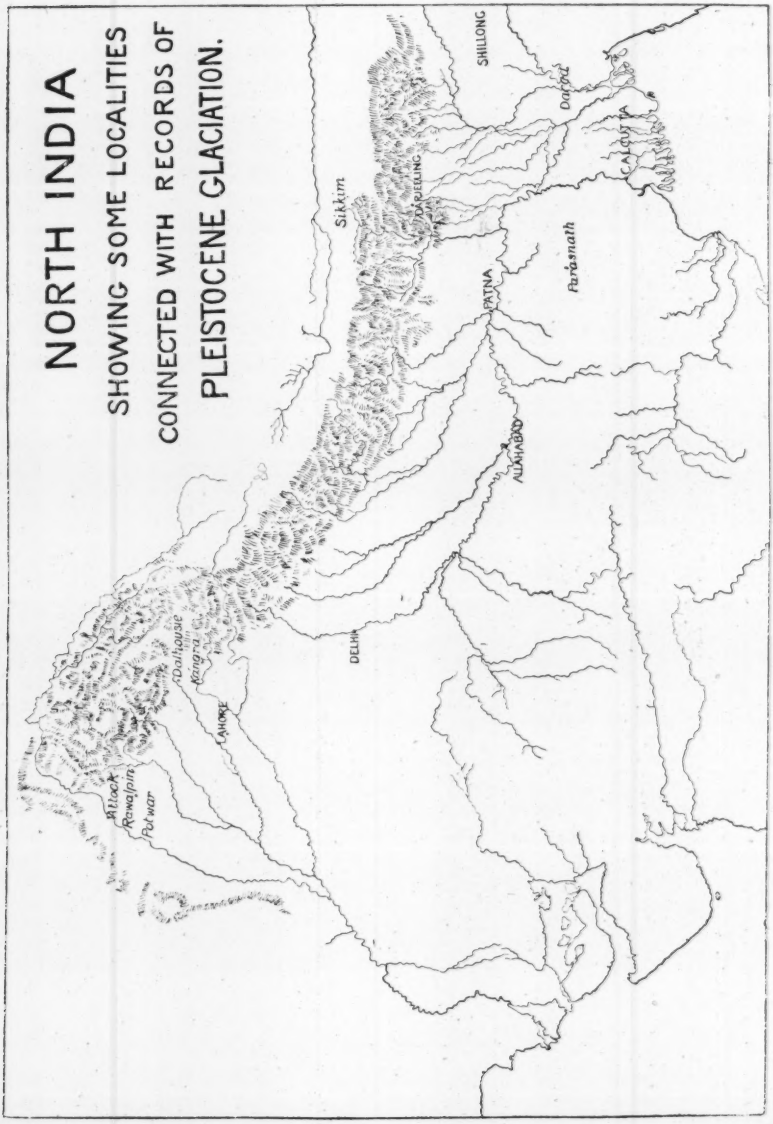


FIG. 3.—The names in capitals are inserted merely for reference. The State of Sikkim lies from the name southward almost to Darjeeling. For Rawalpindi read Rawalpindi.

The lowest direct records of glacial action in the Himalaya appears to be those by the late General C. A. McMahon, who described ice-scratched and grooved rock-surfaces in the N.W. Himalaya, near Dalhousie in the Pangi Valley, at the level of 7,500 feet (McMahon, 1881, p. 310), and a moraine in the same district at the height of 4,740 feet at Mamul (McMahon, 1882, pp. 49–50). Mr. Middlemiss (1896, p. 46) mentions 5,000–6,000 feet as the lowest level at which he has seen reliable traces of glaciers in North-Western India. There appears to be no definite evidence of striated rock-surfaces in the North-Western Himalaya as low as that at Chakung in Sikkim.

The evidence of low-level Boulders and Drifts.—The extension of some form of ice to low-levels in India has been advocated to explain various large boulders and drift deposits. Thus Theobald attributed to transport by floating ice (Theobald, 1877, p. 141) some enormous boulders, as much as 40 feet in circumference, embedded in fine silt and overlying beds of sand and gravel, at the level of below 2,000 feet on the plains of the Potwár near Rawal Pindi in N.W. India. The extension of the same agency to below 1,000 feet above sea-level is claimed in his later paper (Theobald, 1880, p. 221), on the evidence of some large boulders at Attock, where they are marked on his map at a level of a little below 1,000 feet. Theobald (1874, p. 87) claimed the extension of glaciers to the level of about 2,000 feet on some huge erratics, as much as 140 feet in girth (ibid., p. 91), associated with some ridges of drift that he described as moraines, in the Kángra Valley, which is over 200 miles south-east from Potwár, and to the south-east of Dalhousie.

The boulders recorded by Theobald have been often accepted as due to some form of ice transport. Thus Mr. R. D. Oldham (1893, p. 484) remarks that "the erratics of Potwár show that ice in large quantities was not unknown there at one time". Mr. A. B. Wynne (1881, pp. 153–4) accepted the blocks as ice-carried but not as glacier-carried. Mr. Vredenburg has kindly referred me to the memoir on Hazara by Mr. Middlemiss, in which the boulders are explained, from their alignment, as the remains of a local ridge of gneiss, the crest of which had fallen to pieces before it was smothered by silt. Mr. Middlemiss (1896, pp. 46, 241–5) has shown that the erratics of the Sirun and Indus Rivers are outcrops of the Hazara gneissose granite, and he suggests that those of Potwár also are probably "blocks weathered out nearly in situ from a ridge of crystalline rocks covered sparingly by, or protruding through, the Upper Tertiary Sandstones". Middlemiss (ibid., p. 245) adopts the same explanation for the Attock erratics. He concludes (Middlemiss, 1896, p. 46), "I am bound to say that no reliable traces of glaciers at low levels (say below 5,000 or 6,000 feet) have ever come before my notice."

The Kángra Valley Moraine of Theobald is referred to by Medlicott (1876, p. 56) as "the supposed glacial deposits of the Kángra Valley". He regarded the moraine as a ridge left by erosion, though both he and Lydekker felt unable to explain the erratics except by glacial action; and Lydekker (1876, p. 158)

quotes Colonel Godwin Austen as adopting the same explanation for the gneiss boulders along the bed of the Jhelum above Uri.

The evidence of the low-level boulders in North-Western India is apparently not conclusive of any form of glacier action. They were interpreted as implying, at the most, only ice rafts carried by floods; and Middlemiss has shown that this hypothesis is unnecessary.

An analogous claim has been advanced for Eastern Bengal by Mr. La Touche (1910, pp. 198–9). He explains the sheets of alluvium, 100 feet above present river-level, which form the Madhupur Jungle north of Dacca, as deposited by rivers choked with silt during the melting of the ice at the end of Glacial times. He claimed that they are as truly relics of the Glacial period as moraines. This evidence is, however, inferential and does not give any definite indication as to the level reached by the ice which fed the silt-charged rivers.

Biological evidence.—A climatic change in India during recent geological times, which would have enabled ice to exist in Northern India at lower levels than its existing limits, is indicated by various outliers of the Himalayan fauna and flora on the hills of Southern and Central India. Instances of Himalayan plants on Mount Parasnath in Chota-Nagpur, and in South India have been well known since the time of Hooker. The example that probably gives the most precise evidence is the Sikkim Lizard, *Lygosoma sikkimense* (Blyth), now found living on Parasnath to the south of the Ganges plain. Dr. Annandale (1912, pp. 46–8) has summarized and explained its evidence. This lizard is not known to descend lower than the level of 3,000 feet, and owing to its life-history it would appear impossible for it to have spread under existing climatic conditions, from the Himalaya to Parasnath across the low dry plains of the Ganges, for the lizard lays its eggs in wet moss on tree trunks during the rains. Yet a colony is now isolated on Parasnath, 200 miles from its main habitat. Dr. Annandale considers this occurrence as evidence that during the Glacial period the humidity in the Ganges plains was much greater than at present.

6. The Age of the Sikkim Gorges.

The occurrence of the glaciated surface at Chakung affords a useful measure of the age of the lower parts of the Sikkim gorges. The general structure of this part of Sikkim is a peneplane sloping southward to the valley, which runs east and west, and is traversed by the lower Rangit and the Rumman Rivers. The peneplane (Fig. 3) was at the level of about 7,000 feet at Pemionchi, and sloped down to about 5,000 feet along the Rangit–Rumman line, where it was joined by the slope northward down from Darjeeling. The Sikkim peneplane has been dissected by old broad valleys, on the floors of which are a series of narrow, steep-sided gorges. As Professor Garwood (1903, p. 295) has shown, the valley system and larger valleys are of great antiquity, while the gorges are relatively young. The gorges are being rapidly deepened by the corrosion of their beds by the torrential rivers; the valleys are being

widened mainly by landslips. The glaciated surface shows that by glacial times the Great Rangit Valley had been deepened near Chakung to at least 3,600 feet above sea-level. The excavation of a considerable proportion of the 2,500 feet below that level may be post-glacial. That the V-shaped gorges, from 1,000 to 1,500 feet deep, along the bottoms of the main valleys are young, is shown by the sharpness of the faceted spurs and by the existence of high waterfalls, such as that by which the stream on the northern bank of the Great Rangit, a little east of Singla Bazar, leaps from a hanging valley directly into the Rangit River.

FIG. 4.—North bank of the Great Rangit Valley, looking upstream towards Singla Bazar to show the old high-level valley and sudden oversteepening and truncation of the spurs.

CONCLUSIONS.

A glaciated surface at Chakung, at the level of about 3,600 feet above the sea, shows that the glaciers of Sikkim once extended 45 miles south of and descended 5,000 feet lower than the lowest recorded ancient moraines.

The lowest undoubted traces of glacial action on the Western Himalaya appear to be in the Dalhousie district, where the late General C. A. McMahon described moraines as low as 4,740 feet, and glaciated rock surfaces at the level of 7,500 feet.

The glaciated surface at Chakung shows that by glacial times the valleys there had been excavated at least to 3,600 feet above sea-level. A considerable proportion of the excavation of the steep V-shaped gorges on the bottom of the older valleys is probably post-glacial.

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III.—Notes on Myriopoda. XIX.[1] A Revision of some Fossil Material from Sparth Bottoms, Lancs.

By J. Wilfrid Jackson, F.G.S., Assistant Keeper of the Manchester Museum, Hilda K. Brade-Birks, M.B., M.Sc., and the Rev. S. Graham Brade-Birks, M.Sc.

(PLATE IX.)

A careful examination of four fossil millipedes from the Middle Coal-measures of Sparth Bottoms, Rochdale, three preserved in the Manchester Museum and one in Mr. H. Howard's private collection, has revealed some striking features which seem to justify a re-description of the whole material.

These four specimens were originally described by W. Baldwin in Geol. Mag., 1911, pp. 74–80, Pls. III–V.

The first example to be dealt with is that described as

Acantherpestes giganteus. (Text-fig. 1, 2; Pl. IX, Fig. 1.)

[Nos. L 9941 and L 9942, Man. Mus.]

This specimen was obtained by Baldwin in June, 1910, and is the type of his species. The dimensions are those given in the original description.[2] The animal was preserved in a large nodule which, on being split, exhibited both an impression of the dorsal surface and a cast showing the structure of the dorsal plates as well as some of the more ventral features of the animal's body displaced somewhat to the left. A glance at the impression, which exhibits some nineteen body segments, is sufficient to show that we are

[1] The earlier papers in this series have appeared in various scientific publications.

[2] Baldwin, Geol. Mag., 1911, p. 76, Pl. IV, Fig. 1.

dealing with a "flat-backed" millipede,[1] the dorsal plates (or tergites) being furnished with definite lateral expansions. The anterior part of each segment (prozonite) is almost completely hidden by the segment in front. Thus little more is visible of each segment than the posterior portion (metazonite). Each metazonite is characterized dorsally by a definite transverse groove extending to within a short distance of the lateral margin, thus dividing the segment into two unequal parts, an anterior third and a posterior two-thirds. Most of the segments exhibit traces of lateral spine-bases; about the width of each metazonite from its lateral border its posterior portion shows definite traces of one of these lateral spine-bases, but we have been unable to find any trace of other spines on the tergites. This is definitely contradictory to Baldwin's interpretation (Baldwin, op. cit., 1911, p. 76).

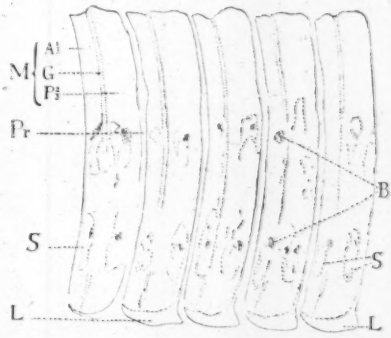


FIG. 1.—Five segments from the cast of *Palæosoma giganteum* (Baldwin sp.) seen from above, showing the undercrushing of the right side of the body and exhibiting most of the essential characters of the tergites and some of the more ventral features as seen through the decorticated dorsal surface. Owing to decortication no left spine-bases are visible, and those of the right side are not seen in this view. M, metazonite; A⅓, anterior third; G, groove; P⅔, posterior two-thirds; Pr, position of prozonite; B, casts of leg-bases; S, spiracles; L, L, lateral expansions. × 1. H. K. B.-B. del.

Turning to the cast we find some twenty-six of the posterior body segments represented. The anterior third of each metazonite is less elevated than the posterior two-thirds. The single row of lateral spine-bases is clearly visible on the right-hand side of the body. On the left, portions of the dorsal surface of each segment are wanting, and the underlying features are partially exposed. On this side of the body, lying beneath each metazonite, there are two elongated spiracle-bearing grooves nearly at right angles to the long axis of the trunk; close to these and corresponding to them are the hollow

[1] Owing to the direction of the relative displacement of the dorsal and ventral parts of the animal's body, it is clear that the right-hand side will be more convex than in life and the left-hand side will tend to be flatter than in life. It follows that when alive the animal was definitely convex dorsally from side to side, but the degree of convexity can only have been slight, and the animal is consequently correctly regarded as a "flat-backed" millipede.

bases of the walking legs, while two underlying ridges of material representing the pleural and sternal plates are exhibited in several cases. These ridges begin at points close to the median line of the dorsal surface of the body, and run obliquely forwards and outwards from the anterior and posterior borders respectively of the posterior more elevated two-thirds of the metazonite. Thus the anterior of the two ridges passes beneath the anterior portion of the metazonite, while the posterior ridge lies entirely underneath the posterior two-thirds of the metazonite. It is not improbable that these ridges are parts of the ventral plates brought into this position by pressure.

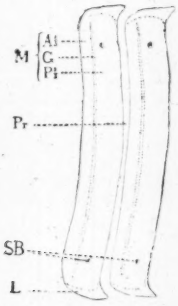


FIG. 2.—A partial reconstruction of two typical posterior segments (5th and 6th from end) of *Palæosoma giganteum* (Baldwin sp.). SB, spine-bases; other lettering as in Text-fig. 1. × 1. H. K. B.-B. del.

Near the anterior end of the fossil the lateral expansions of several of the segments are broken away on the left hand side of the body, and five pairs of legs are represented by five grooves in the matrix. There are clearly two pairs of legs to each typical tergite. On the right hand side one of the legs is seen in oblique section at the anterior end of the fossil, and by passing a bristle up the hollow centre of this leg its position relative to the spiracle close by can be determined beneath the decorticated dorsal surface. By a comparison of this arrangement with that of other segments, it is evident that each leg is associated with a spiracle.

The next specimen is recorded as:

Euphoberia armigera, Meek & Worthen. (Text-fig. 3; Pl. IX, Fig. 2.)

[No. L 9944, Man. Mus.]

This example was discovered by the late Mr. W. A. Parker. The dimensions are those given by Baldwin.[1] The impression alone is preserved in the Manchester Museum, and shows indications of about fourteen dorsal segments with some of the corresponding ventral parts of the body and a series of walking legs. Owing to the imbrication of the tergites, the prozonites are scarcely visible, and thus only the metazonites are to be clearly seen. Each of these is provided with a lateral expansion and is divided transversely by

[1] Baldwin, op. cit., 1911, p. 77, Pl. V, Fig. 4.

a ridge (a groove *in nat.*) into two parts, approximately an anterior third and a posterior two-thirds as in the previous specimen. The metazonites are provided with a lateral row of spine-bases on either side, occupying practically the same position as that of those found in *A. giganteus*. Each tergite is subtended by two pleural plates on either side of the body, and corresponding to each pair of pleurites is a pair of slender legs. The sternites are ill-defined.

We next come to the specimen described as the type of

Euphoberia robusta, Baldwin. (Pl. IX, Fig. 3.)

[No. L 9943, Man. Mus.]

In this example, discovered and presented to the Manchester Museum by the late Mr. W. A. Parker, some fifteen of the trunk-segments next to the head are represented. Owing to imperfect preservation practically nothing of the structure of the head can be distinguished. What Baldwin (op. cit., 1911, pp. 77–8, Pl. V, Fig. 3*a*) takes to be the tail is really the head, and in reading his measurements we must bear this in mind. The narrowest segments are those nearest to the head. The prozonites are

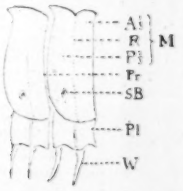


FIG. 3.—*Palæosoma robustum* (Baldwin sp.) (L 9944, Man. Mus.). Two typical segments. R, ridge; Pl, pleurite; W, external outline of walking-leg (segmentation of the appendage not distinguishable); other lettering as in Text-figs. 1 and 2. × 2. H. K. B.-B. del.

hardly visible, being represented by a narrow depressed band in front of some of the metazonites. Once again the metazonites are provided with lateral expansions, and are divided by a transverse groove into an anterior third and a posterior two-thirds. A row of lateral spines is definitely indicated, the remains of the spine-bases being situated about the width of the metazonite from each lateral border, and equidistant from the anterior and posterior limits of the metazonite. As in a specimen we have already mentioned (L 9941), the dorsal surface is considerably decorticated, and the fossil exhibits some of the more ventral features of the body. Thus, in five segments taken as an example, the underlying parts that are visible consist of ten equal ventral rings slightly displaced along the median line owing to crushing. These rings may be interpreted as the impressions of the underlying pleurites with the possible addition of the median sternites lying between the widely separated legs, the position of the bases of the legs being indicated by their hollow casts nearer the middle line, yet closely adjacent to the transverse ovate spiracles, which agree in structure with those of the first specimen described in this paper.

Finally we must consider the specimen described[1] as

Euphoberia woodwardi, Baldwin. (Pl. IX, Fig. 4.)

This example has been kindly lent to us by Mr. H. Howard, of Rochdale, to whom it belongs. The dimensions are those given by Baldwin. The specimen consists of an impression of the head and a cast of some thirty-eight segments of the trunk. In all important characters the structure of the tergites agrees with that of the two preceding specimens. Part of a ramifying series of small fractures of the dorsal surface, just behind the middle of the specimen, is interpreted by Baldwin as a bifurcating spine. We can find no support for this suggestion. The granulated surface of the tergites is exhibited in some places. Owing to the decortication of the dorsal surface, the spiracles, leg-bases, and duplicated pleurites are again visible, and all these agree with the description already given of the same features in the two preceding examples.

As a result of the re-examination of the material before us, we conclude that these millipedes can no longer be retained in that systematic position to which they have been assigned, and as a step in the right direction, we feel justified in establishing the following genus for their reception :—

PALÆOSOMA, gen. nov.

Segments numerous (more than thirty-eight), trunk parallel-sided, narrowing anteriorly and posteriorly, flattened dorsally with lateral expansions, the dorsal surface furnished with a row of lateral spines on either side, head approximately the same width as the anterior body segments, sternites large, two pleura to each tergite; of the tergites the prozonites are short, hardly visible from the dorsal surface, and the metazonites are large, about eight times as wide as long, divided by a well-marked transverse groove into a smaller anterior and a larger posterior portion, each lateral spine provided with a tubercular base.

Genotype: *Palæosoma giganteum* (Baldwin), **char. emend.** Brade-Birks et Jackson.

The two following species fall into this genus :—

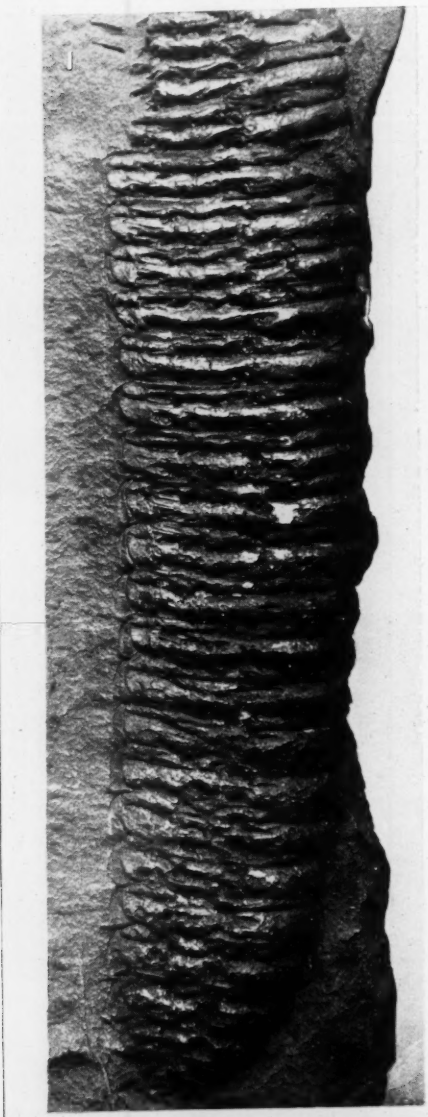
1. *Palæosoma giganteum* (Baldwin), **char. emend. infra.** (Text-fig. 1–2; Pl. IX, Fig. 1.)

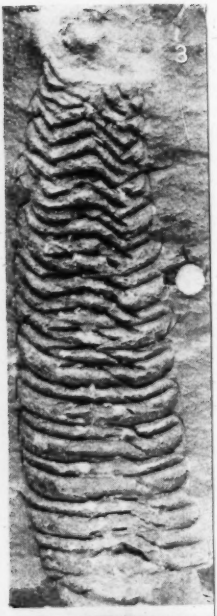
SYN.: *Acantherpestes giganteus*, Baldwin, GEOL. MAG., 1911, p. 76.

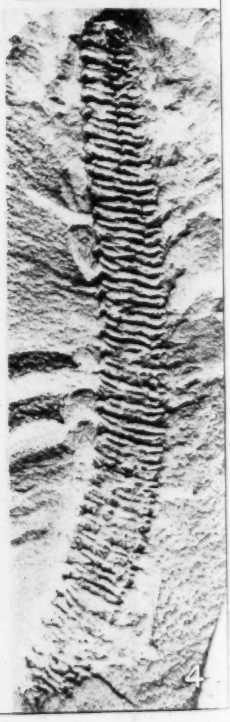
Length of the last seven segments, 45 mm.; breadth of parallel-sided segments, including lateral expansions, 44 mm.; head unknown, prozonites smooth, metazonites only slightly convex from side to side, finely granulated, divided by the transverse groove into an anterior third and a posterior two-thirds, the groove deep near the median line, becoming shallow laterally, to disappear before reaching the lateral borders; lateral expansions prominent, externally foliaceous, and backwardly directed; the spine-base situated the width of the metazonite from its lateral border and equidistant from its anterior and posterior limits (except towards the posterior end of the body (8 segments), where the spines appear to be nearer the posterior border); anal segment small, the posterior end of the body obtuse.

Type: L 9941 and L 9942, Man. Mus.

[1] Baldwin, op. cit., 1911, p. 78, Pl. IV, Fig. 2.







J. W. Jackson, Phot. *Bale & Sons, Imp.*

FOSSIL MYRIOPODA FROM ROCHDALE, LANCASHIRE.

2. *Palæosoma robustum* (Baldwin), **char. emend. infra**. (Text-fig. 3; Pl. IX, Fig. 2–4.)

Syn.: *Euphoberia robusta*, Baldwin, Geol. Mag., 1911, pp. 77–8.
E. armigera, Meek & Worthen, Baldwin, ibid., p. 77.
E. woodwardi, Baldwin, ibid., pp. 78–9.

Not syn.: *Euphoberia armigera*, Meek & Worthen.

Length of anterior seven segments, 22 mm.; breadth of parallel-sided segment (19th from head) 14 mm.; head rounded; eyes present, ocelli in a group, antennæ closely adjacent to the eyes; prozonites smooth, metazonites slightly convex from side to side, divided by transverse groove into an anterior third and a posterior two-thirds, the groove deep near the median line, becoming shallow laterally, disappearing just before reaching the lateral border; lateral expansions narrow and backwardly directed; spine-bases as in preceding species.

Type: L 9943, Man. Mus.

We have made no attempt in the above study to indicate the systematic position of our new genus, but it is our intention to do so in a later paper, which will deal at some length with the classification of certain fossil forms.

EXPLANATION OF PLATE IX.

Fig. 1.—*Palæosoma giganteum* (Baldwin sp.). Genoholotype × 0·79. Cast of posterior end of the body (L 9941, Manchester Museum).

,, 2.—*P. robustum* (Baldwin sp.). × 1·36. Impression of some fourteen posterior segments (L 9944, Manchester Museum), showing tergites, pleurites, and walking legs.

,, 3.—*P. robustum* (Baldwin sp.). Holotype × 1·5. Cast of anterior end of the trunk (L 9943, Manchester Museum).

,, 4.—*P. robustum* (Baldwin sp.). × 0·76. Impression of the head and cast of some thirty-eight body segments. (In collection of H. Howard, Rochdale.)

IV.—Brachiopod Nomenclature: *Clavigera*, *Hectoria*, *Rastelligera*, and *Psioidea*.

By J. Allan Thomson, M.A., D.Sc., F.G.S., Director of the Dominion Museum, Wellington, New Zealand.

In dissenting from Dr. C. T. Trechmann's procedure in rejecting the name of *Clavigera* for certain New Zealand Mesozoic Spirigerids and proposing the new name of *Hectoria* instead, I would like first to express the appreciation of New Zealand geologists for the painstaking work of Dr. Trechmann on the Trias of New Zealand.[1]

The reasons for his rejection of *Clavigera* are thus stated:[2] "*Clavigera* represents a group of specialized bisulcate Spirigerids the affinities of which are discussed later on. I have considered it advisable to rename this group, and have called it *Hectoria*. Hector's description was published without any illustrations, and his subgeneric name closely resembles that of *Claviger* given to a group of the Melanias."

The close resemblance between the names of *Claviger* and *Clavigera*

[1] C. T. Trechmann, "The Trias of New Zealand": Quart. Journ. Geol. Soc., vol. lxxiii, pp. 165–246, 1918.

[2] Loc. cit., p. 216.

does not necessitate the abandonment of the latter name. Buckman[1] discusses an analogous case in Brachiopods in these words: "On the ground that *Cryptopora* was pre-occupied by *Cryptoporus*, and *Atretia* by *Atretium*, Fischer and Oehlert proposed and used the name *Neatretia*. But though in the case of trivial names *cryptoporus* and *cryptopora* would have to be regarded as synonyms, because the termination must be governed by that of the generic name, in the case of the generic name itself there appears to be no necessity to make any change of termination; so that *Cryptopora* and *Cryptoporus* as generic terms ought to be quite distinct enough. It is true that such changes of generic termination were commonly made at one time; but such alterations are now discarded in favour of the original selection." Unless, then, *Clavigera* was accidentally or intentionally employed as a substitute for *Claviger* (in which usage it would be a synonym of *Claviger*), prior to the validation of the name by myself for the Brachiopods under question, the name must stand for the latter group, and *Hectoria* becomes a synonym.

As originally proposed by Hector in 1878,[2] *Clavigera* was a *genus cœlebs*, that is, it was a genus without any species. Hector partly remedied this omission in 1886,[3] when he figured two species, but he omitted to name them. In 1913[4] I discussed the genus and published plates which had been prepared and printed by Hector many years before, and gave names believed to be manuscript names of Hector to four species, viz. *Clavigera bisulcata*, *C. cuneiformis*, *C. gracilis*, *C. tumida*. Although my intention was to give credit to Hector, the responsibility rests with myself, and according to the opinions published by the International Commission on Zoological Nomenclature responsibility takes precedence over credit in publishing new names. In the publication referred to I did not select a genotype, nor has Trechmann designed a genotype for *Hectoria*. These omissions I now rectify as follows: *Clavigera*, Thomson, 1913; genolectotype, *Clavigera, bisulcata*, Thomson. Synonym *Hectoria*, Trechmann, 1918; genolectotype *Hectoria cuneiformis*, Trechmann = *Clavigera cuneiformis*, Thomson.

Hectoria tumida Trechmann is a synonym of *Clavigera tumida* Thomson, and *Hectoria bisulcata* Trechmann of *Clavigera bisulcata* Thomson. Should any subsequent author consider that *Clavigera cuneiformis* and *C. bisulcata* are not congeneric, *Hectoria* may stand for the former. *C. bisulcata* is Triassic and *C. cuneiformis* Jurassic.

Rastelligera equally with *Clavigera* was validated by me in 1913, and the sole species therefore becomes the genotype, viz. *Rastelligera elongata*, Thomson, of which *Spiriferina diomedea*, Trechmann, appears

[1] S. S. Buckman, "Antarctic Fossil Brachiopoda collected by the Swedish South Polar Expedition": Wiss. Ergebn. Schwed. Südpolar-Exped., 1901-3, Bd. iii, Lief. vii, p. 20, footnote, 1910.

[2] J. Hector, "On the Fossil Brachiopoda of New Zealand": Trans. N.Z. Inst., vol. xi, pp. 537-9, 1878.

[3] J. Hector, *Detailed Catalogue and Guide to the Geological Department's Exhibits at the Indian and Colonial Exhibition, and outline of the Geology of New Zealand*, Wellington, 1886, fig. 40, Nos. 2, 3.

[4] J. A. Thomson, "Materials for the Palæontology of New Zealand": Pal. Bull., No. 1, Geol. Surv. N.Z., 1913, p. 49-50, pl. i.

to be a synonym. If the genus is a synonym of *Spiriferina* as Trechmann supposes, the specific name *elongata* should still be used, unless it is preoccupied in that genus. Trechmann's explanation of the comb-tooth structure by partial weathering before fossilization does not appear convincing.

Psioidea stands on a different footing from *Clavigera* and *Rastelligera*, in that it was still left by me a *genus cœlebs*, the only species figured being labelled *Psioidea* sp. innom. It seems desirable to remedy this omission as, although this group is included in *Spiriferina* by Trechmann, the latter genus seems unwieldy and must be broken up. I therefore propose *Psioidea* gen. nov. with genotype *Spiriferina suessi*, Zugmayer, var. *australis*, Trechmann, this course having the advantage of making the invalid *Psioidea*, Hector, a synonym of the valid *Psioidea*, Thomson, 1919, since Trechmann states that the figure published by Hector under the name of *Psioidea* sp. appears to represent his sub-species. Apparently some European Rhætic forms, viz. the second group of Zugmayer's Dimidiatæ, may be transferred to *Psioidea*.

V.—Observations on the Northern Margin of Dartmoor.

By F. P. Mennell, F.G.S., M.I.M.M.

MANY unsolved problems still remain in connexion with Devonshire geology, and there is no more interesting area in the county than that surrounding the Dartmoor granite mass. The investigation of this part of Devonshire has not been completed by the Geological Survey, and most of the northern margin of the Moor remains undescribed.[1] During 1914, 1915, and 1916 the writer at intervals spent a good deal of time in studying the metamorphosed sediments on the north side of the Moor, and although he left England with his investigations incomplete this brief account of the results obtained will, it is hoped, be of service, if only as an indication of what is to be found.

I. East Okement Section.

It will be convenient to take as a starting-point in the description one of those lines of section which offer fairly complete exposures of the rocks across the contact zone or the greater part of it. The best of these is that afforded by the valley of the East Okement River, not far from Okehampton. Above Fartherford railway viaduct this stream flows over the whole width of the metamorphic aureole almost directly at right angles to the strike. The total distance is just over a mile and a quarter, and the succession may be tabulated as follows:—

10. spotted and hardened shales, with gritty bands.
9. chiastolite hornfels.

[1] The Lyd Valley has been dealt with by the writer in Q.J.G.S., vol. lxxi, pp. 623–38. A few general observations are summarized in Q.J.G.S., vol. lxxii, pp. 83–4, 1917. Mr. R. H. Worth has recently read a paper before the Geological Society on the Meldon area, of which only an abstract has yet appeared.

8. altered limestone ("calc-flinta").
x. epidiorite (altered dolerite sill).
6. spotted hornfelses, etc.
5. banded hornfels.
x. epidiorite.
4. chiastolite hornfels.
3. tuff.
2. altered limestone.
1. andalusite hornfels (sericitized).

Intrusive Granite.

The beds on the outer edge of the contact zone, below Farthertord, well seen on Ball Hill, are alternations of thin bands of dark, somewhat fissile shale with lighter-coloured massive bands of grit, or rather, perhaps, of hard gritty shale. The softest dark shales sometimes show faint indications of spotting. The same beds, it may be mentioned, are well exposed in the Simmons Park at Okehampton. The highest beds which are distinctly altered are impure shales, of which an artificial exposure is afforded by an old quarry near the river on the left bank. A study of slices of these rocks does not reveal anything worth noting in the present brief account beyond a mottled appearance due to a cloudy distribution of secondary mica, etc. Gritty beds occur here and there in the river bed intercalated amongst those of a more argillaceous character, and some bands of hard white quartzite are seen. Thin sections of this last show much secondary muscovite. Some of the purer shales are conspicuously spotted, but they do not possess any features of much interest under the microscope. They appear, however, to represent an initial stage in the production of the chiastolite-bearing hornfelses, as the latter show minute chiastolite crystals in the centre of hazy spots, where least crystalline. The chiastolite hornfelses proper, which, unlike the overlying beds, appear to be quite free from gritty bands, are well exposed in an artificial cutting along a track running beside the stream. The beds dip at low angles and are sometimes nearly horizontal. The rock is extremely fresh, and as a consequence the chiastolite crystals are very inconspicuous, so that in the field it looks more like a compact basalt or dolerite than anything else. The altered limestone which underlies it has an outcrop over 100 yards wide. It has a banded structure, like most of the West of England "calc-flintas", and is generally highly silicified and never coarsely crystalline. Nevertheless, it shows occasional seams which contain augite, hornblende, epidote, axinite, and other silicates. Immediately below the limestone comes the upper epidiorite, a narrow band only seen in the actual bed of the river; it outcrops a little below the junction of the Moor Brook with the East Okement. Then we find somewhat varied types of hornfels, sometimes spotted, and much tourmalinized in places. These extend for a short distance above the Moor Brook junction and have among them, apparently, an altered representative of a band which further east contains cordierite. Just below the Moor Brook there is a very gently inclined thrust-plane among these rocks, which are nearly horizontal for some

distance, and then resume a more pronounced dip to the north. A remarkable overfold is seen above the point where the Moor Brook flows into the Okement, close to the mouth of an old adit. Further on we find ourselves on a conspicuously banded type of hornfels, the bedding planes of which form gently sloping surfaces in the river bed. This sometimes contains much biotite or chlorite, while at other points it is extremely like some varieties of "calc-flinta", though it does not seem probable that any great thickness of it was appreciably calcareous. The banded hornfels has the appearance in the field of being the thickest member of the metamorphic series, but more than one overfold can be detected on close inspection. Its thickness may therefore be more apparent than real, a supposition which is borne out to some extent by its attenuation in the Taw section, though it is true it may there be replaced in part by other kinds of rock. The striped rocks are followed by some rather nondescript types of hornfels, though even these are sometimes brown and sometimes grey in different beds, and are here grouped with the banded series. Then comes the lower epidiorite, marked in the river by a waterfall. It is probable that a certain thickness of banded hornfels intervenes between the epidiorite and the lower chiastolite hornfels, but as several specimens selected for slicing proved to be merely highly hornfelsed varieties of the epidiorite this point requires further investigation. The epidiorite, it may be noted, sometimes contains small crystals of tourmaline as well as secondary biotite. The lower chiastolite hornfels, which is much more crystalline in appearance than the upper band, is well seen along the path on the left bank of the river, but apparently nowhere else. Beyond it there are only very fragmentary exposures. The tuff is not seen in situ, and its presence has to be inferred from fragments which are none too common anywhere, but are more abundant on the right bank of the river. The lower limestone, too, can only be discovered after careful search; in fact, I only found the outcrop in the river-bed after my attention had been drawn to the probability of its occurrence by what was to be seen in other localities. The andalusite hornfels is also poorly exposed, though some felspathized and silicified bands of it are to be seen on the river bank. Both this and the overlying limestone can, however, be studied a little to the east on Watchet Hill, near Belstone, the former in artificial exposures and the latter in a number of prominent outcrops.

The question now arises as to how far the section above described can be considered complete. There is nothing in the exposures themselves to suggest that there is any non-sequence, but we are led to that conclusion by the presence, less than half a mile to the east, of a band of tuff. Large masses of this rock are extremely abundant along the lane running from Belstone to Okehampton via Fartherford, and its position probably corresponds with the top of the upper chiastolite hornfels already referred to; indeed, it may be in situ above that rock on the top of the West Cleave, overlooking the Okement, a point which I did not have time to clear up. This is on the assumption that the conspicuous craggy outcrops of dark hornfels represent the chiastolite hornfels at that locality. It is true that the

mineral can seldom be detected in the field, but its presence, often in curious skeleton crystals, is revealed by the microscope. Tuff at this horizon is well exposed at the Meldon railway viaduct, where it has been described by General MacMahon,[1] and fragments indicate its presence all the way from the village of Sourton (*not* Sourton Tors) to near Sticklepath, though it may be absent in places owing to thrusts, as appears to be the case in the bed of the Okement. The lower and more important bed of tuff (not recognized prior to the writer's observation[2] except at Sourton Tors) is only traceable by fragments in the Okement Valley, but is seen between the river and Belstone, and is extremely well exposed in the cliffs overlooking the River Taw.

Structure of the Rocks.

It is worthy of remark that we have here two bands of limestone, two of tuff, two of chiastolite hornfels, and two of epidiorite. In such a disturbed region it is necessary to consider whether this state of affairs may not be attributable to a great overfold of Alpine character. Assuming the axis of such a fold to be somewhere in the banded hornfels series, where there are certainly clear indications of overfolding, the positions of the epidiorite bands on either side of it would fit in quite well with the supposition, and, leaving the limestone out of account, the chiastolite hornfels and tuff would also be in the right position. The limestone, however, which is of considerable thickness on the north, is not recognizable on the south, though it is only right to say that the same appears to be the case with the upper limestone itself on the West Cleave, only a few hundred yards from the river. There is, however, the other (lower) limestone to be accounted for, which occurs in quite the wrong position below the tuff, and also the fact that this is underlain by andalusite hornfels, which can scarcely be a metamorphosed equivalent of the beds above the upper tuff, as these are often of a sandy nature. Moreover, this succession of tuff, limestone, and andalusite hornfels in descending order is seen along the margin of the granite all the way from near South Zeal to beyond Lake, with a regularity which is strongly against such important disturbances having taken place as would be required to account for the want of correspondence north and south of the axis of an overfold. It may also be noted that it would be necessary to assume that some representative of the beds numbered 6 occurs between the hornfels and lower epidiorite. There is no indication of this, and in the Taw section, which is clearer at this point, there is certainly nothing of the kind. What is very suggestive that there is no such simple major overfold as has been discussed, is the fact that so many signs of overfolding are to be seen, and yet in no case do the plicatious result in distinct beds being brought into juxtaposition. This is more in keeping with the idea of minor puckerings of the strata than that of orogenic movements on a grand scale. It may be concluded, therefore, that the apparent order of succession is also the true one.

[1] Q.J.G.S., vol. xlix, p. 380, 1893.
[2] Q.J.G.S., lxxii, p. lxxxiv, 1917.

II. The Taw Section.

Turning now to the River Taw, which crosses the granite contact about a mile east of the Okement, we have a very good section of the lower beds, though scarcely anything is to be seen of the outermost members of the series we have been discussing. The river ceases to flow at right angles to the strike as soon as it gets into the lower limestone, and this fact has also to be taken into account. There are some interesting minor differences between the Taw and Okement sections, but on the whole they correspond very well. Taking what can be seen above the road west of Sticklepath, as well as what the river shows, we have this succession, in which the beds are numbered, where they can be identified, in the same way as along the Okement:—

8. silicated limestone.
x. epidiorite.
7. cordierite hornfels.
x. epidiorite.
6 (?). chiastolitic and spotted hornfels.
x. porphyritic epidiorite.
5. banded hornfels.
4 (?). radiolarian rocks.
3. tuff.
2. silicated limestone.
1. andalusite hornfels.

Some of the beds worst seen along the Okement are extremely well exposed along the banks of the Taw. The lowest member of the series is, however, scarcely recognizable, apart from the artificial exposures at Birchy Lake, and in stray fragments. The limestone is splendidly exposed along the right bank of the stream and shows a very varied mineralogical composition; specimens containing coarsely crystalline garnet, axinite, epidote, augite, hornblende, etc., being readily obtained. There are in it some small mine workings (for copper) now abandoned. The tuff is well seen on both sides of the Taw, though thrusts are no doubt responsible for the fact that it is absent, for a short distance, from the high ground between Belstone and the river. Its total thickness seems to be about 60 feet. It varies in grain from a fine ash to a coarse agglomerate, and, especially at the top, there are numerous alternations of sedimentary material with coarse ash bands a few inches thick. It is therefore clearly the result of a lengthy period of volcanic activity and not of a single paroxysmal eruption.[1] The rock fragments are of acid and intermediate types, to the complete exclusion of basalts, as far as I have examined them under the microscope, and are often highly amygdaloidal. They include some very interesting rhyolites and trachytes, surprisingly little affected by thermal alteration except for

[1] Mr. R. H. Worth has, since these notes were written, put forward the theory that the tuff is of an intrusive nature. I am not aware of any evidence in favour of that view unless the disconnected nature of the outcrops is considered as such. The facts noted here are entirely incompatible with the rock being anything but a true ash bed accumulated under the sea.

the development of minute biotite flakes. The eruptive materials were clearly of classes quite unlike those represented by the lavas now seen in situ at Was Tor and near Brent Tor on the western side of the Moor. The porphyritic augite-andesite of Doddiscombleigh is also quite different from anything to be seen here. Some of the largest fragments in the tuff, which are upwards of 2 feet in length, are of a light-coloured, inconspicuously banded, sedimentary rock of unknown provenance.

Blackish flinty rocks outcrop in the river bed above the tuff, and a specimen sliced was found to contain numerous and quite well preserved radiolarian remains. It is, in fact, a typical radiolarian chert. Two specimens from the sedimentary bands interbedded with the tuff also proved to contain radiolaria. The occurrence of these radiolarian rocks is of considerable interest, as although I have not detected radiolaria elsewhere in the contact zone, they are no doubt to be found by careful search and would serve as useful indices of this horizon. Outside the metamorphic aureole, on what is probably the western extension of these very beds, a band of radiolarian rock occurs along the edge of a patch of woodland, on the main road between Bridestowe and the railway station of the same name.

The dark-coloured beds grade off into the banded types of hornfels so conspicuous in the Okement section. They dip much more steeply, and this is perhaps chiefly responsible for their comparatively narrow outcrop. There is no chiastolite band under the striped rocks corresponding to that of the Okement Valley, and it may be surmised that it is represented by the dark beds, including those with radiolaria. Curiously enough, a well-marked chiastolitic band occurs directly above the lowest epidiorite seen here. This last is a beautiful porphyritic type, containing much secondary biotite, and is well exposed in the river bed under the private footbridge leading into Skaigh Warren. This does not correspond in its position with either of the intrusions seen in the Okement section, though what is evidently the lower of these is exposed close, by at Brinemoor just outside Belstone, with numerous fragments indicating banded hornfels overlying it and chiastolite hornfels below. There is some dislocation, however, at Belstone, as chiastolite hornfels occurs near the village on the high ground on the left bank of the river. This must have reached its present position by faulting, as it does not occur on the opposite side, which has perfectly regular bands of altered limestone in its proper position between andalusite hornfels and tuff. The chiastolite-bearing rock, exposed at Skaigh, is also well seen in the bed of the river, which runs along its strike from Skaigh Warren to near Sticklepath. It has some beds above it, very thin at Skaigh, but much thicker at Sticklepath, where they are worked for road-metal, which are often conspicuously spotted, and appear to correspond to the beds numbered 6 in the Okement section. Above them comes the cordierite hornfels, of which very fresh specimens can be obtained alongside the road just below Skaigh. At this point a narrow epidiorite intervenes between it and the underlying strata. The intrusion is quite different in structure from that exposed in the river bed, and occasionally shows a little

secondary axinite along its margins. The beds above the chiastolite band do not cross the river in this neighbourhood, owing partly to the direction taken by the stream, and partly to the fact that the strike swings round somewhat to the north, so that the representatives of the beds numbered 9 and 11 in the Okement section are here right outside the aureole of metamorphism, and it is therefore difficult to identify or define them with any certainty. West of Sticklepath there is still another band of epidiorite above the cordierite hornfels. Then follows limestone, chiefly altered to a yellowish garnet rock, at one time worked for copper with some success at the Belstone mine. Beyond, indications of contact alteration are absent, and the exposures are so poor that it is difficult to determine where any of the upper beds cross the Taw. The rock burnt for lime near South Tawton is very possibly the unaltered continuation of the metamorphosed upper limestone. It may also perhaps be identified with the limestone formerly worked for lime in the quarry at Drewsteignton, which is said to be fossiliferous. The lower limestone bed has been actively worked for copper in the Ramsley mine at South Zeal. It has been converted into black garnet rock for the most part, but other very interesting types are to be seen. One of these is a garnet-augite-axinite rock in which the garnets show the most remarkable examples of zoning that I have ever seen. This "calc-flinta" probably corresponds with that which is still worked for road-metal further east at Nattenhole Quarry, where the more crystalline bands consist of a very interesting augite-axinite rock containing some felspar.

The andalusite hornfels is seen in a fresh condition along the stream running through Ford Farm, where there are some small openings made to obtain building stone. The rock is interesting petrographically from the fact that it is here a biotite-andalusite hornfels, whereas further west it is muscovite-bearing. The exposures have revealed from time to time the presence of numerous veins emanating from the granite varying from several feet to a fraction of an inch in width, and containing visible pink crystals of derived andalusite. The lower "calc-flinta" has also been exposed in a prospecting shaft (said to be for arsenic) at Ford Farm. In addition to the usual silicates, sections from this locality sometimes show a very strongly birefringent mineral, which is no doubt datolite. The tuff seems to die out in the neighbourhood of Sticklepath. All the rocks are poorly exposed beyond South Zeal, and I have not attempted to trace the various beds beyond that village.

III. Westward Continuation of the Series.

West of the Okement the beds are not at first very easy to follow. Near Okehampton fragments of tuff and epidiorite are to be found in abundance on the golf links, but it is not easy to say where they occur in situ except that there is an outcrop of epidiorite just below the Artillery Camp. A number of narrow seams of garnetiferous rock with shale partings probably represent the upper limestone, and are well exposed at the Camp Hill Quarry. These dip south and thus indicate a sharp local synclinal fold. Both red and black garnets are present, and these are embedded in a matrix which is sometimes

chiefly hornblende and sometimes a fine felt of wollastonite fibres. One variety shows in thin slices beautiful rosette-shaped sections of pink garnet scattered through an aggregate of pale-green hornblende crystals. Fragments of chiastolite-bearing rocks are to be found below the quarry and also occur plentifully on the fields to the east. These no doubt link up with the uppermost beds containing that mineral in the Okement section. Above the camp masses of tuff are the most conspicuous feature, and obscure the other beds until the andalusite hornfels is reached.

Better exposures are to be seen along the Redaven brook, which runs from the foot of Yes Tor to join the West Okement above the village of Meldon. The succession of andalusite hornfels overlaid by limestone and succeeded in turn by tuff, which is again covered by blackish and banded types of hornfels, is as clear as in the Taw Valley along the banks of the Redaven, and also those of the West Okement. It may be traced beyond the village of Lake, where the beds begin to pass out of the contact zone, and lower horizons are represented along the edge of the granite. These latter are of a more gritty character, generally speaking, though they include what may be altered radiolarian chert above Lake Viaduct, and crystalline limestone on the north-western slopes of Great Nodden, where we encounter the rocks described in my paper on the Lyd Valley. There is probably more than one fault in this neighbourhood, of which I was not able to complete the examination.

Returning to the Meldon area, the well-known intrusion of fine-grained topaz-bearing granite or granophyre may be noted as intrusive in what is here called the banded series, which is unusually calcareous at this point. Further west, in the cliffs overlooking the Okement, veins connected with it invade the lower tuff. Above these rocks comes the upper limestone, which has been worked for lime in a large quarry now abandoned, but which thins out to the east into narrow seams interstratified with shale. Westward it is represented along the strike by coarsely crystalline calc-flinta, full of interesting minerals, which affords a good instance of undoubted introduction of silica in the course of the contact metamorphism of limestone. These beds are in all probability the same as worked in the large quarry near Bridestowe, outside the metamorphic area. It may be noted that wollastonite, rare further east, is occasionally abundant in the upper limestone, while the lower limestone is sometimes converted into idocrase-wollastonite rock, which is also to be found among the numerous xenoliths in the "aplite" quarry. Datolite and scapolite are also known to occur. In this section chiastolite-bearing rocks seem again to be the uppermost sediments that have undergone marked alteration. The upper tuff, first described by MacMahon, outcrops near the railway and is well exposed on one side of the viaduct. No epidiorites are seen along the Redaven, but a narrow sill, much tourmalinized, is seen in the big quarry worked by the railway company for ballast a little to the east, as to the horizon of which I am by no means certain.[1] A much more prominent basic

[1] Restrictions connected with the War prevented me re-examining the quarry or inspecting the railway cuttings.

igneous intrusion outcrops on Sourton Tor and on the high ground north of it, where it is of a porphyritic type, like that seen at Skaigh, and apparently on the same horizon.

NOMENCLATURE.

For convenience of reference it may be well to give local names to the rocks that have been dealt with in these pages. The rapidly alternating shaly and gritty rocks, so well seen along the Okement at Ball Hill and in the Simmons Park, may appropriately be named the *Okehampton Beds*. The underlying strata, to which most attention has here been devoted, and which are essentially a calciferous shale series, are perhaps best termed *Sticklepath Beds*. Their upper limit may be defined as the point where the gritty bands first make their appearance. The series itself is, so far as I have been able to see, entirely free from grit. The base is that of the shales which in the metamorphic area are represented by andalusite hornfels. They appear to rest near Lake[1] on beds of which a considerable thickness is gritty throughout, as seen near the railway at Lake and Southerley, though they include sharply folded (? radiolarian) rocks near Lake Viaduct, banded calcareous shales east of Southerley, as well as the purer shales represented by the andalusite hornfels of Great Nodden, where a seam of limestone and some grit bands also occur. These *Southerley Beds*, as they may be termed, rest on the *Lydford Beds*, which have at their top the Downtown calc-flinta. They are essentially, however, a thick succession of shales of the type which are rather chloritic than strictly argillaceous in character, and are represented in the contact zone almost exclusively by cordierite hornfels.

Before concluding, it is both a duty and a pleasure for me to acknowledge the constant aid and frequent companionship of my friends Dr. E. H. Young and Mr. H. J. Ward, of Okehampton, during the investigation of the interesting rocks which form the subject of this paper.

REVIEWS.

I.—THE PALÆONTOGRAPHICAL SOCIETY. Vol. LXXI, April, 1919. Volume issued for 1917. 4to; pp. 170. Printed for the Society. Agents for the Society, Dulau & Co., Ltd., 34–36 Margaret Street, W. 1.

THE volume issued this year, although lacking in its usual bulk, owing to the further rise in printers' prices and the general shortage of paper, etc., does not suffer as to the quality either of its printed matter, its plates, or the authors' contributions of valuable text.

1. Dr. Arthur Smith Woodward presents part iii (the concluding part) of his monograph on the Fossil Fishes of the English Wealden and Purbeck Formations (pp. viii, 105–48, and 12 pages of explanation of pls. xxi–vi). The text also carries seven additional

[1] There are probably several faults or thrusts about here.

figures; amongst these latter may especially be referred to figs. 36–9 and 41, the restorations of the skeletons of *Pleuropholis formosa*, *Leptolepis dubius*, and *Lepidotus minor*, as fine examples of delicate drawings by Miss G. M. Woodward. So far as known, the fishes of the Wealden and Purbeck formations are essentially Jurassic and not mingled with any typically Cretaceous forms. Most of them are indeed (in the author's opinion) specialized and evidently final representatives of the Jurassic families to which they belong, not to be regarded as possible ancestors of the fishes of Cretaceous and later times.

2. The index and title-page complete the first volume of Mr. F. W. Harmer's great work on the "Pliocene Mollusca of Great Britain", with a systematic list of genera and species (pp. xii and 463–83). A view is added of the pit of "Waltonian" Crag at Little Oakley from which the author obtained the shells of about 650 species of Mollusca and upwards of 100 specimens of Polyzoa. This concludes the Crag volume for the year.

3. Dr. W. Spencer follows with part iv of his monograph on British Palæozoic Asterozoa (pp. 169–96), illustrated by twenty-five text-figures of anatomical details of *living* and *fossil* forms, which greatly assist the student in understanding the structure of these very interesting organisms and their life-history and functions, so that the dry bones of the Palæozoic starfishes, interpreted by their modern representatives, live again.

4. Mr. Philip Lake adds part v of his monograph on the British Cambrian Trilobites with four excellent plates and 31 pages of text, embracing *Ctenopyge*, *Leptoplastus*, *Euryeare*, *Peltura*, *Beltella*, *Parabolinella*, *Angelina*, *Dikelocephalus*, *Dikelocephalina*, and *Apatokephalus*. Mr. T. A. Brock's figures are excellent.

We trust the splendid work carried on by the Palæontographical Society may not be permanently hindered by the evils arising as an "aftermath" of the War, which has affected the cost of printing and publishing of all scientific work more or less severely.

II.—The Lower Cretaceous Floras of Queensland.

1. Mesozoic Floras of Queensland. By A. B. Walkom, D.Sc. Part II: The Flora of the Maryborough (Marine) Series. pp. 18, with 2 plates. And a Geological Note, Map, and Section, 2 pp., by B. Dunstan. Queensland Geological Survey, Publication No. 262, 1918. Parts III and IV. The Floras of the Burrum and Styx River Series. pp. 70, with 7 plates. And a Geological Note and Sections, by B. Dunstan, pp. 6, with 1 plate and 2 text-figures. Ibid., Publication No. 263, 1919.

2. The Geology of the Lower Mesozoic Rocks of Queensland, with special reference to their Distribution and Fossil Flora, and their Correlation with the Lower Mesozoic Rocks of other Parts of Australia. Proc. Linn. Soc. New South Wales, vol. xliii, pt. i, pp. 37–115, 2 plates and 6 text-figures, 1918.

1. These memoirs form further instalments of Dr. Walkom's valuable work on the Triassic, Jurassic, and Cretaceous plants of

Queensland (see GEOL. MAG., Dec. VI, Vol. V, p. 516, 1918). The author's analysis of the different floras, showing the percentages in which the chief plant groups are represented, are particularly suggestive.

Large collections of marine fossils have been obtained from the Maryborough Series (Lower Cretaceous), the predominant forms being Pelecypods and Cephalopods. In association with these animal remains, there are a number of fragmentary plants; about 34 specimens have been obtained, representing 14 species. Of these 34 specimens, 11 are of *Pagiophyllum*, 8 of *Tæniopteris*, 4 of *Araucarites*, 2 of *Ginkgo*, 2 of ? *Taxites*, 2 of indeterminate roots, and 1 each of *Equisetites*, *Sphenopteris*, *Ptilophyllum*, ? *Pterophyllum*, and silicified wood. This list indicates a flora in which Gymnosperms largely preponderated.

The flora of the Burrum Series, which was formerly described as Lower Trias–Jura in age, is found by Walkom to be typically Lower Cretaceous and undoubtedly homotaxial with such floras as the Wealden of Europe and the Lower Cretaceous (Neocomian) of North America. Thirty-six species have been obtained, 22 of which are Gymnosperms, while 13 belong to the Filicales. Walkom draws attention to the fact that one leaf-type, which he describes as "? *Dictyophyllum* sp.", may possibly be Dicotyledonous.

The Styx Series proves to be somewhat younger than the Burrum Series, and it is suggested that it may be the equivalent of the Albian stage. The association of Dicotyledonous leaves with a number of typical Mesozoic plants makes it clear that the age of the strata is Cretaceous, probably Lower Cretaceous. The flora shows considerable resemblance to the Patapsco Flora of Maryland and Waikato Heads Flora of New Zealand. The species represented include Equisetales (1), Filicales (4), Cycadophyta (3), Coniferales (3), and Dicotyledons (3).

2. In the general paper cited above, Walkom discusses the conditions prevailing in Queensland in Lower Mesozoic times, and the geography of the Australasian region during that period—basing his conclusions in part upon his detailed study of the palæobotanical evidence.

A. A.

III.—THE MAIDENHAIR TREE IN SPITSBERGEN.

GINKGO ADIANTOIDES (UNGER) HEER IM TERTIÄR SPITZBERGENS nebst einer kurzen Übersicht der übrigen fossilen Ginkgophyten desselben Landes. By A. G. NATHORST. Geol. Fören. i Stockholm Förhandl., Bd. xli, H. iii, pp. 234–48, 4 text-figures, 1919.

THIS paper records the occurrence of *Ginkgo adiantoides* in Spitsbergen, associated with *Populus arctica* and other leaves characteristic of the Tertiaries of this region. This species, which is probably identical with the living *G. biloba*, has been obtained from many localities in Europe, from horizons ranging from the Eocene to the Upper Pliocene. The present discovery carries its known range further to the north, since Braganza Bay and Green Harbour (lat. 78° N.), where it has now been found, lie considerably nearer

the Pole than the locality in Greenland which has hitherto been its most northerly recorded station (lat. 70° N.).

Professor Nathorst follows his account of *Ginkgo adiantoides* by a general review of the Mesozoic Ginkgophytes of Spitsbergen. He points out that genera belonging to this group are abundantly represented in beds between the Jurassic and the Cretaceous, equivalent to the Wealden and uppermost Portlandian. He draws attention to the singular fact that the Wealden beds of Europe display no corresponding richness in Ginkgophytes, which, on the contrary, have here passed through their period of abundance in the Rhætic and Lower and Middle Jurassic. Why, he asks, do the Ginkgophytes reach their maximum in the Polar regions later than in Europe? He does not propose any answer to this riddle, but points out that its solution is bound up with the problems of climatic changes and plant migrations.

A. A.

IV.—The Iron and Steel Industry of the United Kingdom under War Conditions. By F. H. Hatch, Ph.D. pp. xii + 167, with plates and diagrams. Privately printed, 1919.

THIS handsome and well-illustrated volume, which has been privately printed for Sir John Hunter, K.B.E., is described on the title-page as a record of the work of the Iron and Steel Production Department of the Ministry of Munitions. Out of the ample material at his disposal Dr. Hatch has constructed a remarkably interesting story of well-directed enterprise and success in the face of overwhelming difficulties of all kinds. It is not easy for the non-technical reader to grasp the magnitude and complexity of the task to be faced by the band of self-sacrificing and courageous men who undertook to evolve order out of chaos, to reconcile conflicting interests, and to carry out schemes which not only contributed in the highest possible degree to the military and naval successes of the Allies at the moment, but also kept in view the needs of the future, so that after the War, in spite of everything, the iron and steel trades of the country might be in a stronger position than they were before. It is that wise and statesmanlike foresight that forms, perhaps, the most remarkable feature of the fascinating story unfolded by Dr. Hatch in these pages.

When the formation of the Iron and Steel Production Department was undertaken by Sir John Hunter the demand for steel was growing rapidly, while the supply of raw materials from abroad was seriously curtailed: the demands of the military authorities on labour were urgent, and in many places industrial unrest was making itself felt. It was necessary to balance all these conflicting factors so as to obtain the best possible results with the means available. Home resources of material had to be utilized to the full, and methods modified to suit their special characters, while labour-saving devices of every possible kind were introduced. Prisoner labour was also utilized to some extent, but with not very satisfactory results.

The most remarkable feature of the whole scheme was the immense increase in the production of steel from phosphoric ores by

the basic processes. This was necessitated by the shortage in the supplies of foreign Bessemer-grade hæmatite ores, which had to be replaced by British supplies, derived mainly from the Jurassic ironstones of the Midlands and Cleveland. While the output of ore from the latter region remained more or less normal the tonnage from Lincolnshire and the Midland counties increased largely, and noteworthy developments took place in Northamptonshire, and especially in Oxfordshire. Even the Upper Lias stone of the island of Raasay was drawn on to some extent, though this is unlikely to be an important source of future supply. A considerable amount of the more phosphoric grade of Kiruna ore was also purchased in Sweden through the efforts of the Department.

The immense increase in steel-production also necessitated the development of British resources of limestone, dolomite, and refractories, as well as the building of a large number of new coke-ovens of improved types. All this was also carried out successfully by the officials of the Department in the face of great difficulties as to transport, labour and financial questions.

It should be fully recognized that the country owes a debt of gratitude also to the iron and steel makers, who loyally co-operated with the Ministry of Munitions, often against their own personal interests, and rendered great services to the nation at large by their readiness to assist the Government and each other to make the best of the available resources. The organization called into existence for the special purposes of the War has done notable work in laying the foundations of ultimate victory, and we trust that its wise and far-seeing measures will in time of peace lead to a permanent increase in the prosperity of the iron and steel trade, which is one of the mainsprings in the industry of this country.

V.—The North Riding of Yorkshire. By Capt. W. J. Weston, M.A., B.Sc. Cambridge County Handbooks. pp. viii + 161, with illustrations and diagrams and two coloured maps. University Press, Cambridge, 1919. Price 2*s.* 6*d.* net.

THIS volume forms another of the excellent series of county geographies issued by the Cambridge University Press, and deals with the fourth in size of the English counties, the North Riding being only exceeded by the West Riding, Devonshire, and Lincolnshire. An area of this size naturally shows wide variations in structure, topography, climate, soil, and industry, as is well brought out by the author. The North Riding is clearly divisible into three main regions, the hills in the west consisting of Carboniferous rocks, the central plain of Trias and drift, and the Jurassic moorlands of the east, with the lower ground on the same formation extending from Helmsley, Pickering, and Scarborough to York. All this is classical ground to the geologist, since it is associated with the names of William Smith, Young and Bird, Phillips, and other pioneers of the heroic age, while even in recent times many problems of the greatest interest have there been studied

with effect. In speaking of the topography of the county, it may, perhaps, be noted that even within the recollection of the present reviewer the name Cleveland Hills has received a very wide extension, mainly at the hands of geologists. Strictly speaking the Cleveland Hills are only the northern escarpment of the great Jurassic area, overlooking the plain of the lower Tees, but now by customary usage the name has gradually encroached towards the south, extending first to the line of the Esk, while by some writers it is apparently made to include the whole of the moorland region down to the Vale of Pickering, more properly known as Blackamoor. It is probably now too late to enter an effective protest against this proceeding, which has received the sanction of high scientific authority.

There are few more remarkable features in the history of this country than the development of the Cleveland district proper. A hundred years ago Middlesbrough was an uninhabited mud-flat. It is now a town of 120,000 inhabitants and the centre of a world-wide industry. This development is solely due to the occurrence of iron-ore in the Lias. Serious mining began about 1837 at Grosmont, though cargoes had been shipped from the coast platform about Kettleness many years before. The commencement of working at Eston in 1850 was not the first start, as stated by Captain Weston, although it was undoubtedly of the greatest importance. As every one is aware, the Cleveland output of ore is now far greater than that of any other British ironfield, and it is possible that in the immediate future the older workings in the Esk Valley may be restarted.

The author of this book has been on the whole very successful in bringing out the great importance of geology in the North Riding: a few minor slips occur, but nothing of much significance. Perhaps the worst feature of the book is the coloured geological map; a geologist may well ask, why is the tint of the "Lower Oolites" made practically indistinguishable from that assigned to the Whin Sill, and still more, why is this latter labelled "granite"? Without a very careful scrutiny the non-geological reader would certainly gain the impression that the eastern moorlands consist for the most part of granite: it needs a keen eye to detect the difference of tint and stippling.

Captain Weston has succeeded in his difficult task of giving a brief, clear, and interesting account of a very large subject, preserving a due balance between the different parts, and presenting a most readable account of a region which can yield to none in beauty of scenery and historic interest, and as a happy hunting ground for the geologist, the botanist, and those interested in all the other branches of natural history in the broadest sense of this much-abused term.

R. H. R.

VI.—The Mineral Industry of the Union of South Africa and its Future. By P. A. Wagner. South African Journal of Sciences, September, 1918. pp. 34, with a map.

THIS is a reprint of Dr. Wagner's Presidential Address to Section B of the South African Association for the Advancement of Science. It consists essentially of two parts, the first being a comprehensive review of recent developments in the mineral industries of the Union, while the second part is mainly devoted to the future and the possibility of further discoveries. It is difficult to know what to select for special comment from the great mass of valuable information contained in the first part, but one or two points may be briefly mentioned. Dr. Wagner takes a distinctly optimistic view as to the development prospects of the metalliferous deposits of the great Insiswa intrusion in Zululand, which may perhaps turn out to be a notable rival to Sudbury. This appears to be an excellent example of gravitative differentiation accentuated by the immiscibility of sulphide and silicate magmas. Another local industry which has of late actually reached a position of world-wide importance is asbestos mining. South Africa now leads the world in the production of this useful mineral, as also of corundum. It is interesting to note that the phosphates of Saldanha Bay are now being actively exploited on a large scale with successful results. With regard to the phosphate beds in the Ecca Series in Natal, it might have been mentioned that these were described by Dr. Hatch nine years ago in his Report on the Mines and Minerals of Natal. South Africa is now beginning to take a place among the iron-smelting countries of the world, four blast furnaces being now in operation.

The second part of the address is occupied by a consideration of the geographical distribution of minerals: the Union is divided into nine provinces, mainly based on geological formations. It is pointed out that large tracts of country are still virtually unprospected, and the future may yet hold surprises in store, though probably nothing equalling in importance the diamond pipes of Kimberley or the Rand goldfield remain to be discovered. Yet there is always hope.

R. H. R.

VII.—Notes on the Formation of certain Rock-forming Minerals in and about Glass Furnaces. By G. V. Wilson. Trans. Soc. Glass Technology, vol. ii, pp. 177–216, 1918.

THIS paper contains an account of some interesting and important observations made by the writer in connexion with recent work on glass-making in Scotland. The opportunity was afforded for the most part by the accidental bursting of a tank furnace at the Kinghorn Bottle Works in Fife; the molten material, amounting to about 70 tons, flowed into a space below the furnace and took several days to cool. During this slow cooling several types of crystalline material were formed and reactions took place between the molten glass and the bricks of the furnace, leading to the formation of a series of minerals, mainly silicates of lime and alumina. Other

specimens obtained from various sources were also examined petrographically, and the results obtained are here discussed from the theoretical and practical points of view.

The following are the chief minerals observed: wollastonite, quartz, tridymite, melilite, augite, sillimanite, corundum, biotite, and magnetite, as well as a mineral having the composition $3CaO.2SiO_2$, not known to occur in nature. In the general body of the glass the chief minerals found were wollastonite and tridymite, and their presence is of much interest as indicating that owing to the presence of other substances acting as fluxes the crystallization took place below the inversion-points of pseudowollastonite to wollastonite and of cristobalite to tridymite. Wollastonite was very abundant in the specimens and showed a strong tendency to spherulitic aggregation, a feature noted also in other cases of a similar nature. Augite and quartz were found only in thin strings of glass injected into cracks in the bricks or at the junctions of glass and brick. The augite is a variety containing a good deal of manganese.

Under certain conditions wollastonite, augite, tridymite, and quartz, can all crystallize out from the same melt, while felspar, magnetite, and biotite are formed by the corrosive action of glass on brick. Wollastonite, melilite, augite, and the $3CaO.2SiO_2$ compound were produced in partly assimilated limestone fragments enclosed in molten glass. The action of molten glass on aluminous materials used to contain it in the form of glass-house pots, furnace linings, and crown bricks leads to the formation of sillimanite and corundum in considerable quantities, some specimens examined containing very well developed crystals of both mineral.

It is impossible here to detail all the results following from this careful examination of the material available and the theoretical deductions to be drawn from it: the paper is of great interest and should be studied carefully by all petrologists interested in the genesis of the minerals of the igneous and metamorphic rocks.

VIII.—The Geology of Northern Norway.

Sulitelmatrakten. By G. Holmsen. Norges Geol. Undersök. Aarbok for 1917, iii, pp. 44, and 2 plates (with English Summary).

Fjeldstrøket Fauske-Junkerdalen. By J. Rekstad. Ibid. iv, pp. 66, with 7 plates and a coloured map (with English Summary).

THESE two memoirs give an account of the geology of the tract of country between the Saltenfjord and the Swedish frontier, which includes the well-known copper-mines of Sulitelma, now being extensively worked. It is an area of high mountains and plateaux, some points rising to 6,000 feet above the sea, and supporting several important glaciers. The region consists of gneisses, crystalline schists, amphibolites, and marbles, penetrated by igneous rocks of Caledonian age, ranging from serpentine to granite, the latter occupying the largest area. Some interesting examples of sheared and folded conglomerates are described and

figured. The ore-deposits of Sulitelma occur in highly metamorphosed rocks of Cambrian and Silurian age in close association with amphibolites (sheared gabbros). The origin of the ore-bodies is still a matter of controversy, Vogt considering them to be derived directly from the gabbro magma, while Sjögren holds that they have been formed metasomatically by the action of aqueous solutions.

IX.—Yorkshire Type Ammonites. Edited by S. S. Buckman. Photographs by J. W. Tutcher. Part XVIII. London: Wesley and Son. March, 1919.

THIS part completes the second volume of this most useful publication. Accordingly it furnishes a table of contents, the precise dates of publication of each page and plate, zoological and chronological lists of the genera dealt with, an index, and other necessary matter. It is noted that the first two volumes contain 163 plates, illustrating 137 species. There are still some type-ammonites of Yorkshire to be redescribed, but it is proposed now to extend the scope of the work by including type-specimens of Jurassic ammonites from other localities in the British Isles. The price will be raised to 10*s.* net for each part, consisting of 10 to 12 plates and text, but should circumstances permit the number of plates may be increased.

The chief species figured in this part are: *Ammonites impendens*, Young & Bird, referred to *Arietites*; *Ammonites longævus*, Bean, cit. Leckenby, which gives rise to two new genera, the lectotype becoming *Longæviceras longævum* and the other syntypes becoming *Pseudocadoceras boreale*. Supplementary plates are given of *Gagaticeras funiculatum*, *Beaniceras costatum*, and *Fimbrilytoceras fimbriatum*.

X.—Recent Advances in Rhodesian Geology. By H. B. Maufe. Pres. Add. Proc. Geol. Soc. S. Africa, 1919, pp. xxi–xxxvi.

IN this address Mr. Maufe gives a comprehensive general account of the geology of Rhodesia, as worked out by himself and his colleagues on the Geological Survey. The subject is treated mainly from the stratigraphical point of view, and the petrographical characters and probable origin of the leading rock-types are discussed. The outstanding feature of Rhodesian geology is the enormous preponderance of the oldest systems, composed of crystalline schists and intrusive bathyliths, which occupy most of the country, while newer formations are scantily developed. Hence there are many gaps in the geological history of the country. Special attention is drawn to the curious problem of the origin of certain types of banded ironstones, which have been shown to be altered felsites, while it is also believed that many of the so-called conglomerates are really of intrusive igneous origin, the "pebbles" being lenticular masses of rather more basic composition derived from the same magma as the base. A noteworthy feature of the older series is the enormous volume of basic igneous rock, now represented by epidiorite, and perhaps exceeding in magnitude even

the Karroo dolerites. The Umkondo formation is referred by Mr. Mennell to the Waterberg, which it resembles lithologically. The Karroo system covers a good deal of ground in Rhodesia, but no tillite has been found. The age of the red sandy Kalahari Beds is still uncertain: they represent a period of very arid conditions at some time between the close of the Stormberg and the present day: it is impossible as yet to be more definite than this.

R. H. R.

CORRESPONDENCE.

A QUARTZOSE CONGLOMERATE AT CALDON LOW, STAFFS.

SIR,—In the August number of the GEOLOGICAL MAGAZINE, p. 384, Mr. F. Barke, Chairman of the Geological Section of the North Staffs Field Club, states that the quartzose conglomerate recently described by us (GEOL. MAG., February, 1919, pp. 59–64) "was discovered in 1905 by members of the Geological Section of this club, and the fact recorded in the Trans., vol. xl, p. 85, 1905–6".

When our note was being written we had before us the article to which Mr. Barke refers, and which reads: "In opening out the new quarry at Caldon Low, on the eastern side of the hill, an interesting section has been exposed. The beds of limestone dip steeply to the east, and are badly faulted; traces of lead can be seen in some of the fissures, and there were signs of old workings on the side of the hill. At the southern end of the quarry occurs a limestone breccia containing Bunter pebbles; a swallowhole, now filled with cave earth, has been cut across, communicating with a fissure; the latter is said to have been traced for a considerable distance down the hill until the explorers were stopped by water—it has been partially filled up by refuse from the railway cutting; towards the northern end the limestone becomes deeply stained with hæmatite. The beds are almost unfossiliferous; amongst the fossils noticed were *Productus humerosus*, *Orthotetes crenestria* (*sic*)."

We fail to understand how the description given by us of the position occupied by the conglomerate section can be made to agree with the above-quoted statements. It may be observed that:—

1. The quarry in which occurs the conglomerate section is situated on the north-west flank of the hill, and not on the eastern side.

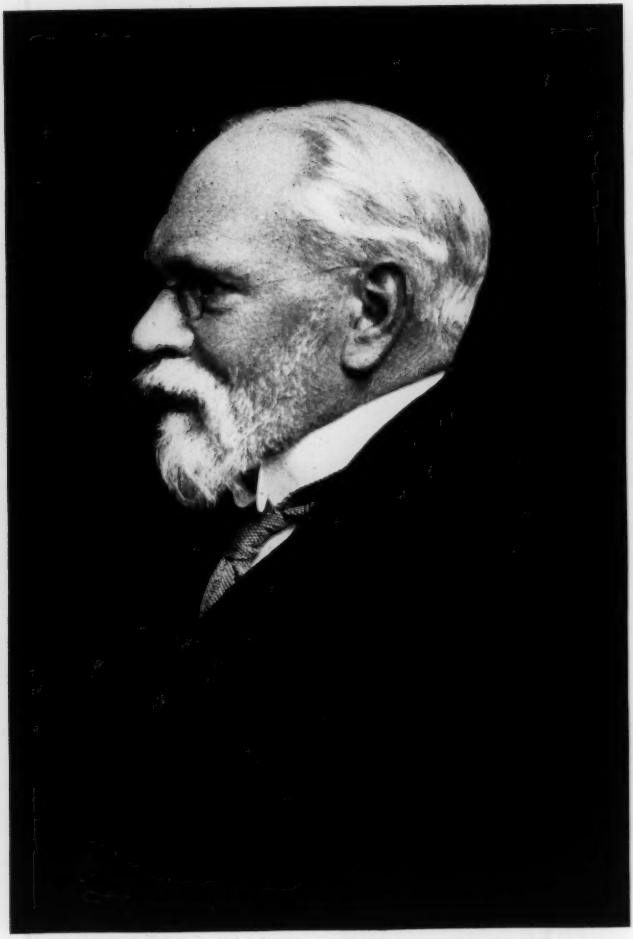
2. The beds of limestone do not dip steeply east: the underlying *humerosus*-limestones are practically horizontal; the conglomerate is obscurely bedded in its lower portion, while the upper beds dip N.N.W. at an angle of 30°.

3. No definite evidence of faulting is visible.

4. The conglomerate extends round the north-east flank of the Low from the north-east end of the quarry.

5. Finally, the pebbles present do not resemble the typical Bunter pebbles in general facies, while the presence of an abundant and highly characteristic Upper Carboniferous fauna places them very considerably earlier than Bunter times.

Thus, we venture to think we were justified in concluding that the breccia with Bunter pebbles recorded by Mr. Barke in 1906 was



a deposit totally different in character and in significance from that described by us.

J. Wilfrid Jackson.
W. E. Alkins.

Manchester.
August 13, 1919.

OBITUARY.

JOHN HOPKINSON, F.L.S., F.G.S., F.Z.S., F.R.M.S.,
Assoc. Inst. C.E.

Born 1844. Died July 5, 1919.

(PLATE X.)

By the death of Mr. John Hopkinson English geologists have lost an excellent fellow-worker, and many of them (like the writer) a valued friend.

Born at Leeds in 1844 John Hopkinson came south while still young, residing, with his family, for the greater part of his life in Hertfordshire, first at St. Albans, and afterwards at "Weetwood", near Watford, the home of his grandfather.

Although engaged in business in London[1] John Hopkinson possessed a keen interest in every branch of natural science, and gave all his leisure to their study and advancement, devoting himself more particularly to the pursuit of geology, palæontology, microzoology, and meteorology.

His love of open-air studies led him to associate with the members of various field-naturalists clubs, and his training and education in early life well fitted him for the management of their affairs, and he speedily became interested in the promotion and welfare of these societies which have done so much in the past fifty years to nourish the pursuit of science in this country.

In conjunction with the late Dr. A. Brett he founded the Hertfordshire Natural History Society in 1875, and served it in various capacities up to the time of his death, being President in 1891–3. It was while residing in St. Albans that John Hopkinson took a prominent part in founding the Herts County Museum, where, at his own expense, he provided the instruments and equipment for the Meteorological Station. It was mainly on his initiation that "the Conference of Delegates" at the British Association was founded in 1880, and he served as its Chairman in that year and as its President in 1917.[2] He did much valuable work for the Ray Society, being its Treasurer from 1899 to 1902, and its Secretary since that time. He published in 1913 a *Bibliography of the Tunicata*, and was part author with J. Cash and G. H. Wailes of a monograph on *British*

[1] As a partner in the well-known firm of J. & J. Hopkinson, piano manufacturers, retiring only a few years ago on the business being converted into a limited liability company.

[2] An abstract of his address (presented on July 6, 1917) was given in the Geological Magazine for that year, pp. 371–4.